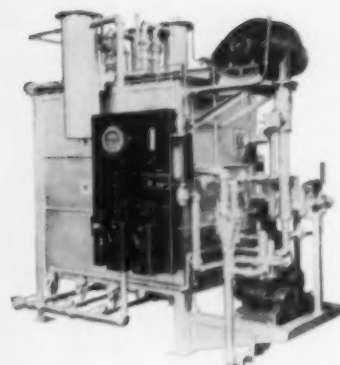
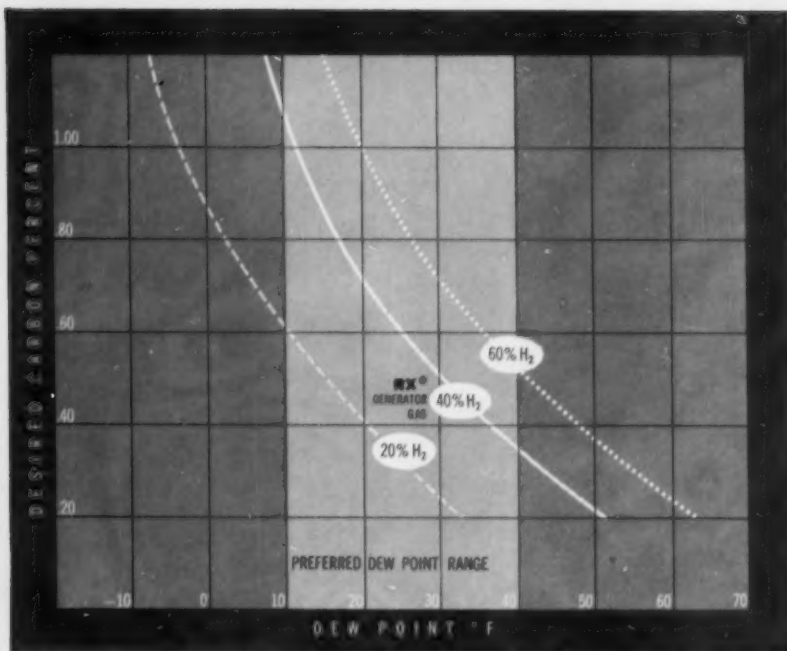




**PROGRESS**



Light area on the chart shows preferred control band for quality gas carburizing. Surface® generators (right) make control easy.

## Which atmosphere gas gives the best case control?

'Surface' RX® generator gas is the accepted answer in hundreds of plants because of its easy and accurate carbon potential control. Whether you're doing gas carburizing, homogeneous carburizing, dry cyaniding, clean hardening or carbon restoration, RX® generator gas gives you (1) maximum carburizing rates in the least furnace space, (2) near-theoretical case gradients, and (3) either high or low carbon surfaces without sacrificing these other advantages.

This versatile endothermic gas contains about 20% CO, 40% H<sub>2</sub>, 40% N<sub>2</sub>, and very small controlled amounts of CH<sub>4</sub>, H<sub>2</sub>O, and CO<sub>2</sub>. It is "designed" for the accepted dew point method of controlling carbon potential: its easily measurable trace of water vapor gives it a readily controllable dew point value for each variation of its composition, from rich to lean.

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# Metal Progress

Volume 69, No. 6

June . . . . 1956

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The cover design, based on a coil of copper wire, by DONNA ZACKMAN, was a prizewinner in the annual competition conducted by *Metal Progress* at Cleveland Institute of Art.

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- Titanium Alloy Reclamation by Vacuum Annealing,**  
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- Effect of Molybdenum in Iron and Steel, by Alvin J. Herzig** . . . . . 72  
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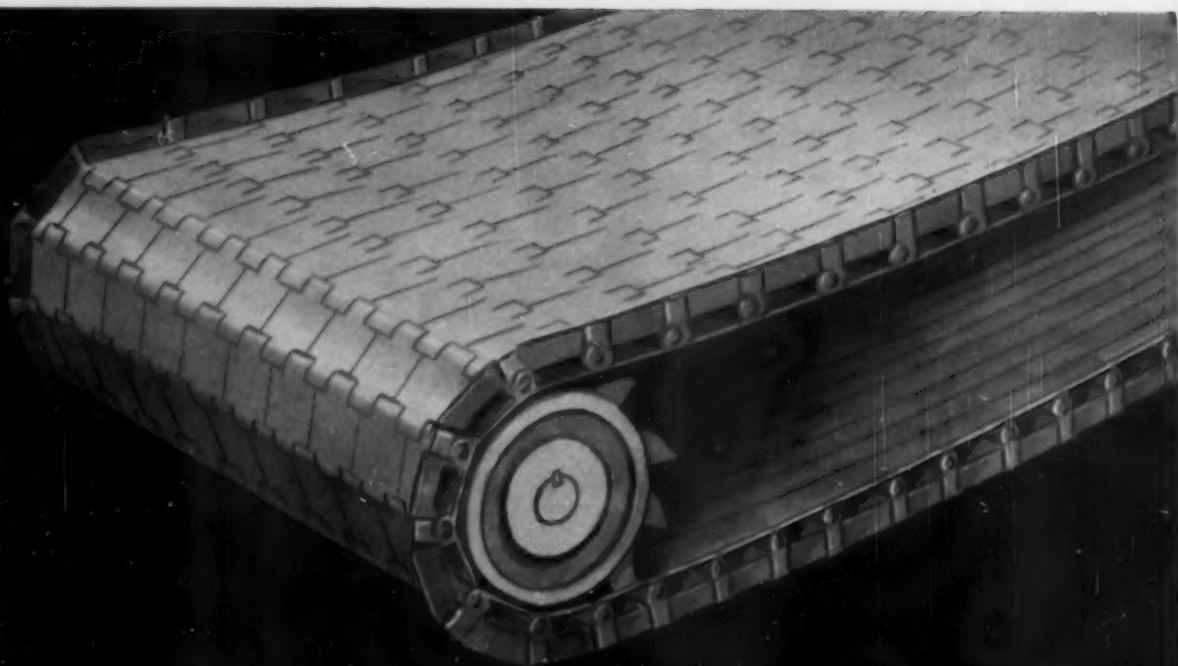
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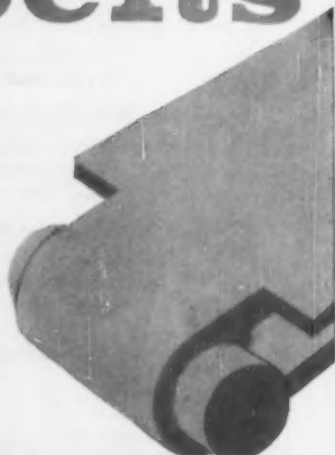
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# there goes the profit...



use of impure ammonia for metal treating is a frequent cause of discoloration on finished parts

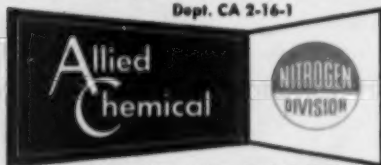
The ammonia you use for metal treating can add to your profits—or reduce them! Impurities like oil or moisture may cause discolorations that land finished work in the salvage box. They are also a common cause of poisoned catalysts and other costly dissociator troubles.

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# As I was saying...



PRESIDENT SCHAEFER and I have been on the go since the 15th of February, and all I know is what I read in the letters from Miss Evelyn "Friday", a genuine encyclopedia of information. So here's the latest from her typing machine.

"Dear Mr. E.: The mail just arrived—more than 500 pieces—and three people are now busy alitting and sorting. The members' dues are coming in better than usual, and I am informed the smallest number in years will be dropped for nonpayment. Dorothy Cowell is pleased with her promotion as 'the top' in the membership department and wishes to thank you.

"Mr. Thum has finished the editorial work on the Chromium Book, and the manuscript is now ready to go to the printer.

Mr. Bayless reports he has 88 papers

for the Publications Committee to review and select some 40 for the Cleveland Metal Congress. The committee will have a two-day meeting to make the selection. Mr. Bayless has two secretaries doing Fitz's work. Fitz was in the office yesterday. She seems very happy with wedded life, and plans to pick up some pin money and while away her idle moments by 'styling' for the printer some of Dr. Brasunas's Metals Engineering courses.

"Mr. Wells placed a report on your desk indicating the Cleveland Metal Show is 99 44/100% sold. It was the heaviest advance sale in history, with more than 400 exhibitors. The hotel reservation forms will go to the printer very soon.

"Mr. Thum just returned from a week at Oak Ridge, and said to tell you that the symposium on thorium is coming along in splendid shape and should be a big hit at the Cleveland convention.

"Dr. Beck (chairman of the A.S.M. Seminar Committee) wrote you today. Dr. Andrade (the 'father' of creep research) of Cambridge, England has been invited to present the Saturday evening lecture during the creep seminar at the Cleveland convention.

"You had two letters today offering to purchase the 'winter-wear' you offered for sale in your recent column. It is really encouraging to know that your column is gaining readers. These two, added to the three of us who have to check it, show that reader interest is picking up.

"Dr. Lyman had a conference with Glen Riegel last week on Handbook committees. The Doctor is delighted to have Mr. Riegel on the staff of the Metals Handbook, and is busy lining up a number of other scientists to assist in the tremendous amount of work involved in getting out the next edition (in two volumes).

"You had a call today from that good-looking Beaver Falls high-school English teacher, the W & J graduate, accepting your offer to become affiliated with the A.S.M. I know that news will please you. The *Metal Showman*, which you said he would edit, and the Metals Engineering Institute's lessons will certainly have no split infinitives, or unnecessary commas, colons, exclamation points and/or questions.

"Kingsley Given will arrive on June 1 for his 18-month jaunt with the A.S.M. He secured a Sabbatical leave of absence (from Kansas State University), and with the summer vacation periods should be of great help (as assistant director of the Second World Metallurgical Congress, Chicago, Nov. 2 to 8, 1957).

"Marjorie Hyslop (corresponding secretary of the 2nd World Metallurgical Congress) told me she has received more than 115 applications from overseas, and 50,000 leaflets are being sent abroad for distribution to members of learned societies in the free countries of the world.

"A lot of national and world events are certainly taking place in our office. Everybody is so enthusiastic. It would have done your heart good to see the real happiness of the staff when they got the word that the Board had selected the staff's favored site for the new headquarters and the A.S.M. of Tomorrow.

"See you next week—EVELYN."

Thanks, Evelyn, for an informative letter.

Cordially yours,

*Bill*

W. H. EISENMAN, Secretary  
AMERICAN SOCIETY FOR METALS

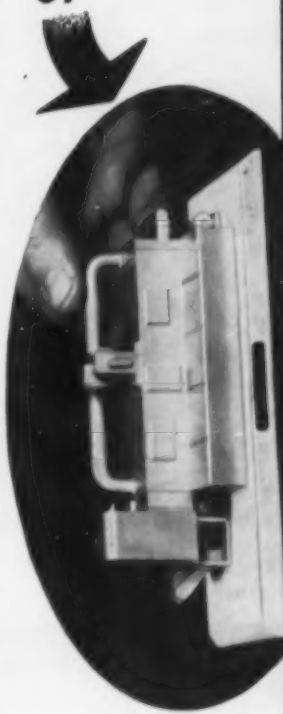
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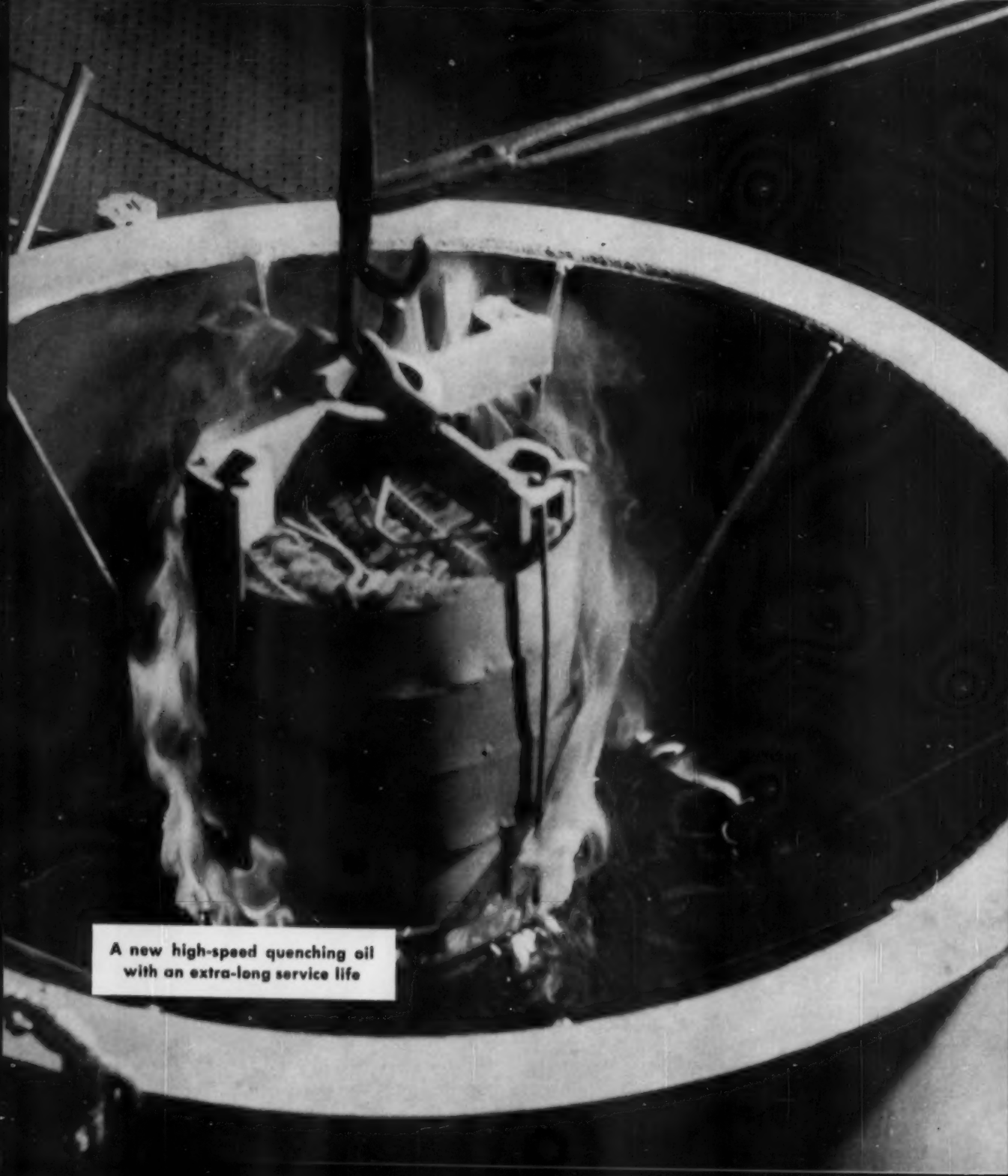
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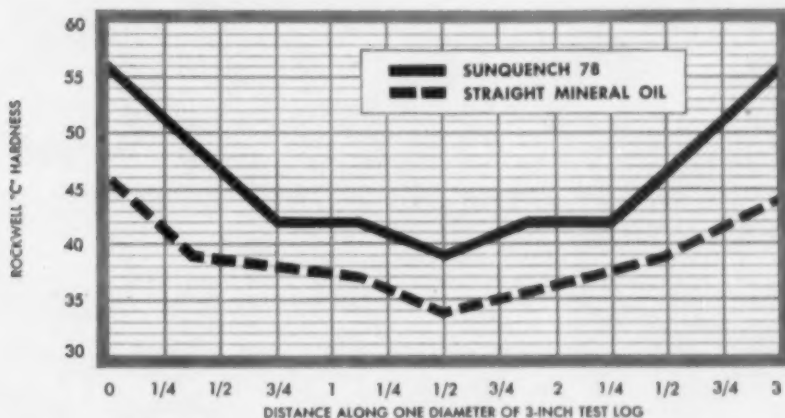
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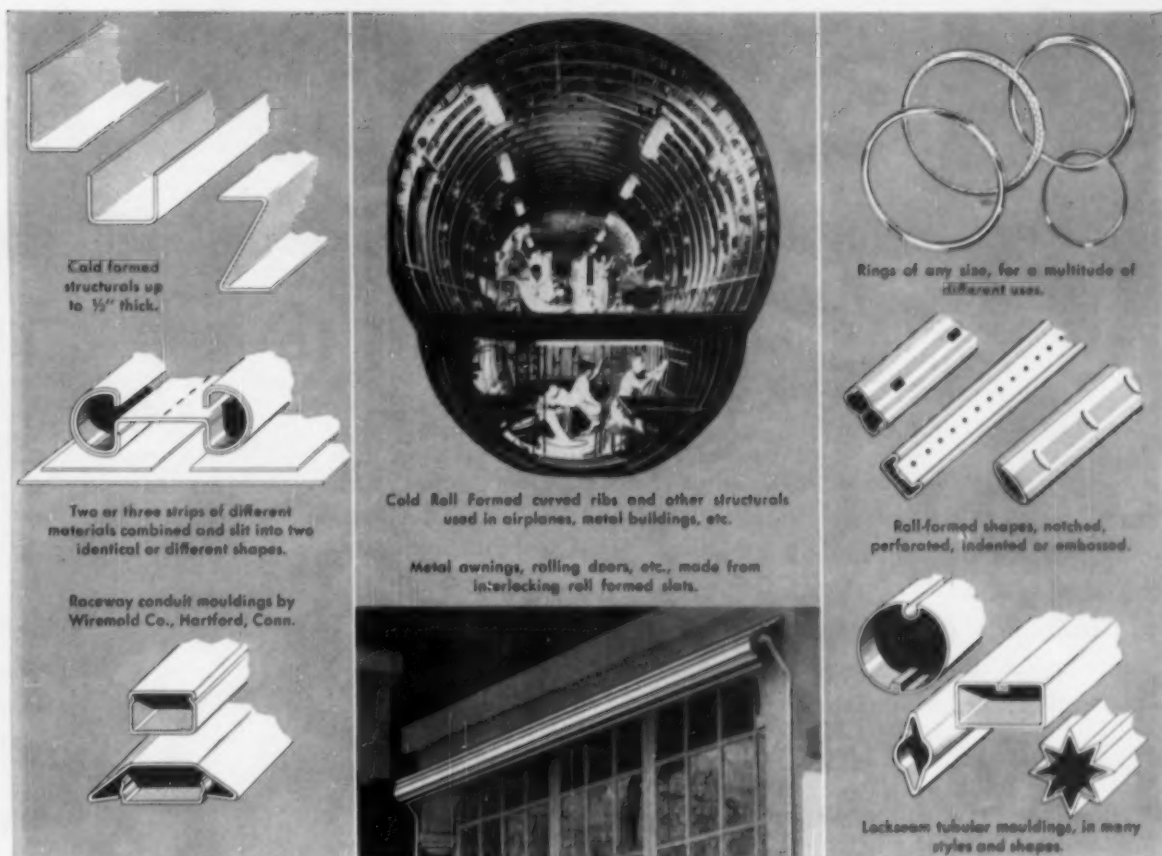
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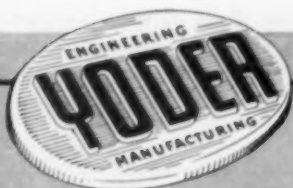
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# APPLICATION and EQUIPMENT

## new products

### Induction Heating

A new series of electronic induction generators has been announced by the Induction Heating Corp. These units are available in seven sizes, ranging from 10 kw. to 50 kw. of power output. A new tank circuit allows maxi-

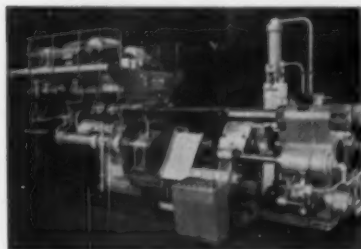


mum power into the work with almost any work coil. Generators are in enclosed cabinets. A self-contained heat exchanger provides complete cooling of components by the recirculation of distilled water. A system of check lights indicates any abnormal operating conditions.

For further information circle No. 1433 on literature request card, page 32-B.

### Aluminum Extrusion Presses

Lake Erie Engineering Corp. has announced the first of a series of 2300-ton self-contained hydraulic aluminum extrusion presses. These machines are



capable of extruding billets from 6 to 9 in. in diameter and up to 30 in. in length at speeds up to 48 in. per min. They are of the four-column, long-stroke type and of an extra heavy and rugged construction.

For further information circle No. 1434 on literature request card, page 32-B.

### Hydraulic Tubing

A new type of hydraulic tubing has been announced by Summerill Tubing Div. A special annealing process, with controlled atmosphere, completely treats the inside of the tube as well as the outside. The improvement in finish on the inside of the tube virtually eliminates oxidation, scale and other adhering foreign matter that could restrict the flow of fluid and clog hydraulic systems. The extreme cleanliness is expected to reduce fabricating and cleaning costs and the uniform surface permits easier bending and fitting.

For further information circle No. 1435 on literature request card, page 32-B.

### Cleaning

A new batch-type airless abrasive blast cleaning machine has been announced by Wheelabrator Corp. This

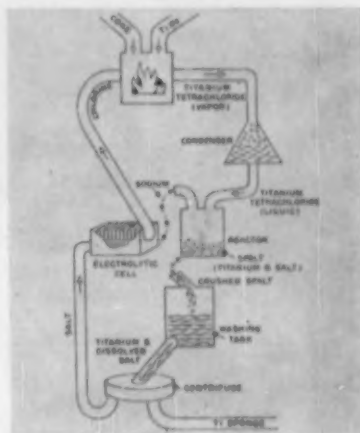


machine has an operating load capacity of 28 cu. ft. It is designed for cleaning sand, scale, oxides and other contaminants from any work that can withstand a tumbling action. The Super Tumblast has a single high-capacity airless blast unit that throws 830 lb. of abrasive per minute or more than twice as much as any other similarly sized wheel.

For further information circle No. 1436 on literature request card, page 32-B.

### Titanium

The first heat of titanium metal sponge produced by the sodium-reduction process has been announced by Electro Metallurgical Div. This is the first commercial production of titanium sponge in the United States by a

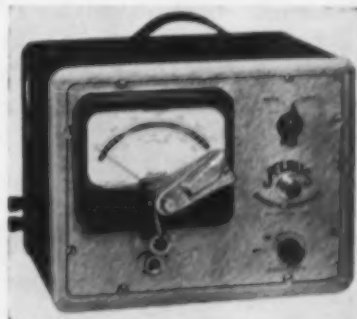


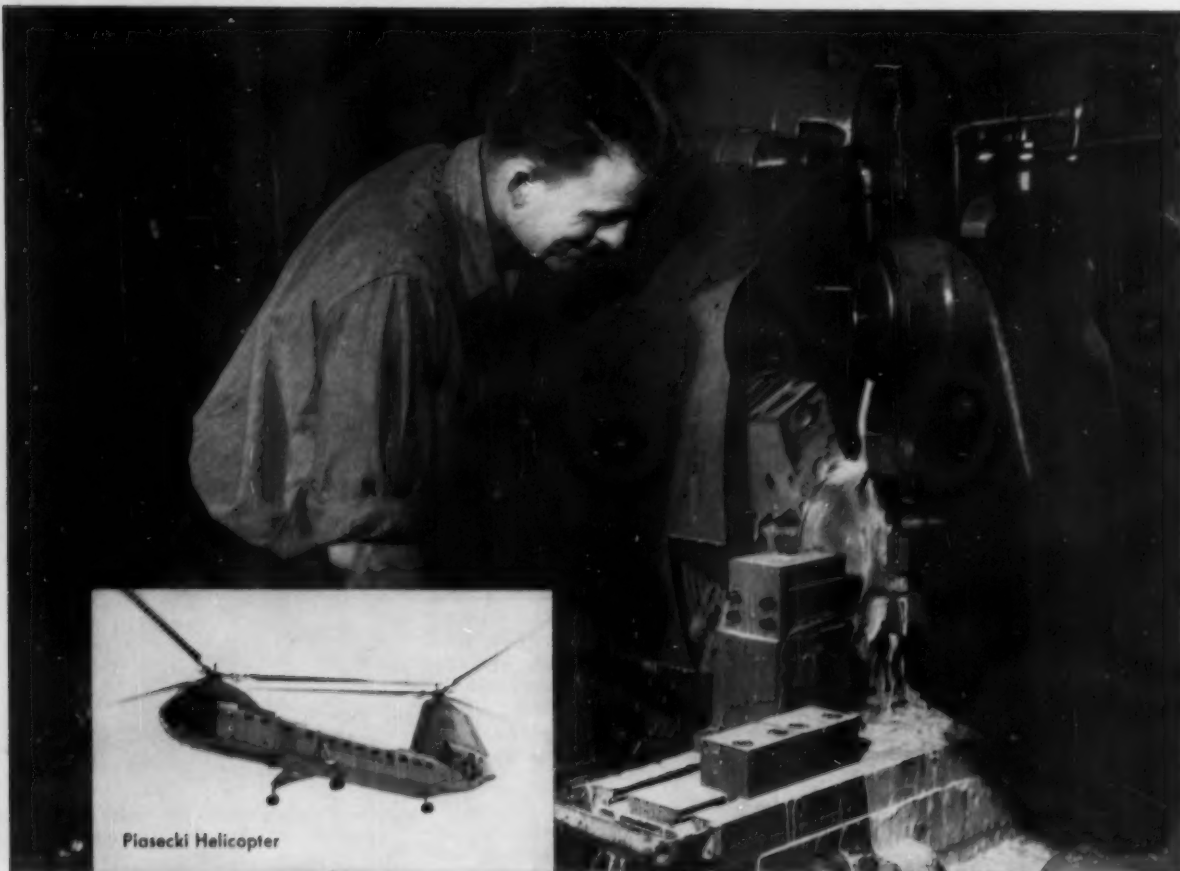
method other than the magnesium-reduction process. The company has had this process in operation on a pilot and prototype plant scale at its laboratories in Niagara Falls. The titanium sponge is remelted into ingots by producers of titanium mill products and commercial shapes. The plant has a capacity of 7500 tons a year. The flow diagram shows the transformation of titanium ore into titanium sponge.

For further information circle No. 1437 on literature request card, page 32-B.

### Temperature Control

A new automatic indicating and controlling pyrometer for use with chromel-alumel, iron-constantin, and platinum-10% rhodium thermocouples has been announced by the Jelrus Co. The controller operates on a photoelectric principle, eliminating moving





Piasecki Helicopter

## Sun's Heavy Duty Emulsifying Cutting Oil excels on high-alloy aircraft steels

S.E.C.O. Heavy Duty handles all machining jobs requiring an emulsifying cutting oil. Piasecki Helicopter's large job shop at Morton, Pa., found this out three years ago when S.E.C.O. HD\* replaced two expensive heavy-duty soluble oils in machining fan hubs.

Extremely versatile and moderately priced, S.E.C.O. HD has been doing an exceptional job in cutting a variety of high-alloy aircraft steels for Piasecki.

For more information about S.E.C.O. HD, see your Sun representative. Or write to SUN OIL COMPANY, Philadelphia 3, Pa., Dept. MP-6.

### WRITE FOR FREE TECHNICAL INFORMATION

- Cutting and Grinding Facts
- Disposal of Waste Emulsions
- New Improved S.E.C.O.
- S.E.C.O.—Mixing Instructions
- S.E.C.O. HD



\*TRADE-MARK

INDUSTRIAL PRODUCTS DEPARTMENT  
**SUN OIL COMPANY**  
Philadelphia 3, Pa. © SUN OIL CO.

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METAL PROGRESS

parts and contact wear. A beam of light, directed at the mirrored meter face, is interrupted by the pyrometer needle to actuate a simple control circuit. The controller comes equipped with thermocouple break protection and compensation of thermocouple circuit resistance up to 10 ohms. Portable units are available, as well as those for panel mounting.

For further information circle No. 1438 on literature request card, page 32-B.

### Abrasive Wheels

A new line of small wheels for polishing metal with portable hand tools has been announced by Minnesota Mining and Mfg. Co. The wheels are

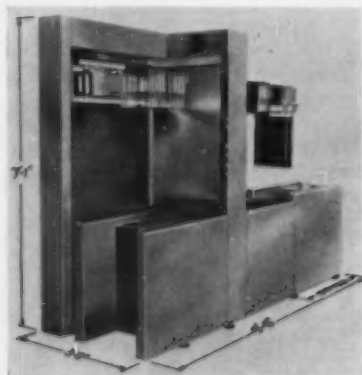


composed of die-cut pieces of coated abrasive cloth, bonded with resin and locked into a hub. They are particularly suited for work in the appliance, stainless and sheet steel fabricating, metal polishing, plating and tool and die industries.

For further information circle No. 1439 on literature request card, page 32-B.

### X-Ray Film Developing

A new, fully automatic processor for developing and drying up to 300 exposed X-ray films per hour has been announced by Hard & Co. It is intend-



ed for use where the volume of films to be handled per day is high, or where the developing time cannot be trusted to other than exact machine timing. However, the light lock of the machine is so arranged that it may be used for manual processing of films. The machine is 9 ft. long, 85 in. high,

36 in. wide. It operates on either 110 or 220 volt, single-phase, 60 cycle power.

For further information circle No. 1440 on literature request card, page 32-B.

### Rust Remover

Development of an alkaline material for the removal of rust, paint and primer in one dip and rinse operation has been announced by Turco Products. This powdered compound removes light rust in less than a minute. Heavy rust and multiple paint layers usually require a few minutes immersion. Turco alkaline rust remover contains no cyanide compounds and does not require complicated electrolytic equipment. Metals derusted are no more subject to rusting than is new metal.

For further information circle No. 1441 on literature request card, page 32-B.

### Roll Leveller

F. A. Woehr Machine Co. has announced a roller leveller for use in fabrication operations. Its 11 alloy steel rolls flatten mild steel, hard-tempered steel, stainless steel, alumi-



num, brass or copper, in widths up to 42 in. and in gages from 0.020 to 0.093. It may be used for straightening sheet stock, coil stock, producing cut lengths of flat sheet from coil and for work annealing deep drawing steel. This machine operates at a standard speed of 56 ft. per min. Power source for the roller leveller is a gear-head, single-speed motor.

For further information circle No. 1442 on literature request card, page 32-B.

### Creep-Rupture Tests

A new multiple creep-rupture testing machine of the lever type, in which four specimens can be held simultaneously under loads up to 4000 lb. has been announced by Baldwin-Lima-Hamilton Corp. A special four-



**Can 0.0005 inch  
precision strip simplify  
your product design?**

From 0.0005 in. to 0.040 in. thick and 0.090 to 6 in. wide, these alloys are available as special-tolerance strip:

**Beryllium Copper  
Phosphor Bronze  
Nickel Silver  
Brass  
Chromium Copper  
Stainless 17-7PH  
Invar  
Magnetic: High Nickel**

Some immediately available. Others rolled to order in 2 to 21 days. Can be supplied in coils or straight lengths with slit or filed edges—also cadmium plated.

Write for Bulletin 7  
**TODAY.**

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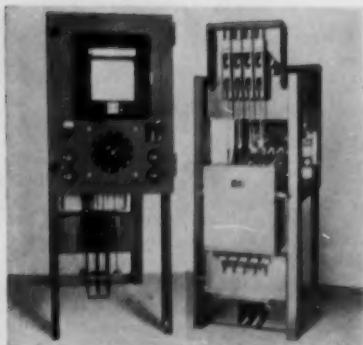
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specimen electric furnace under automatic temperature control will hold specimens at any temperature up to 1800° F. Running time counters total to 10,000 hr. in 0.1-hr. intervals.

**For further information circle No. 1443 on literature request card, page 32-B.**

### Furnaces

A new suspended hearth-type furnace with radiant tube heating has been announced by Surface Combustion Corp. Suction-type radiant tubes prevent contamination of prepared atmosphere. Operating temperatures are from 1400 to 1700° F. The snap hearth furnace is applicable to clean hardening, dry cyaniding and carbon restoration.

**For further information circle No. 1444 on literature request card, page 32-B.**

### Ultrasonic Cleaning

General Ultrasonics Co. has announced a new ultrasonic transducer for cleaning, degreasing, pickling, plating, and other physical and chemical processes. It is completely sealed, metal jacketed, stainless steel lined and thermostatically protected. Provision is made for draining and recirculating process liquids during



operation. The treatment chamber is 20 in. long, 8 in. wide and 6 in. deep with a liquid capacity of 2½ gal.

**For further information circle No. 1445 on literature request card, page 32-B.**

### Control

Industrial Electronics has announced a new electronic control in-

strument for use with sensing elements, which are built into the gage heads for automatic measuring applications such as gaging and sorting, weighing, pressure control, fatigue testing, inspection, and thickness control. Control is provided by means of two power relays, which can be adjusted to operate at any desired control point, and on any of the four sensitivity ranges. These relays can be made to operate on plus or minus tolerances, two successive plus tolerances or two successive minus tolerances, by internal switching.

**For further information circle No. 1446 on literature request card, page 32-B.**



### Endothermic Generator

A new, reversible, endothermic gas generator with self-cleaning action has been announced by Connecticut Gas Atmospheres. Different models will handle from 500 to 300 cfh. Cooling of gas is accomplished by two heat exchangers.

**For further information circle No. 1447 on literature request card, page 32-B.**

### Microhardness Tester

A new combination microhardness tester and metallurgical microscope of the nondestructive type has been announced by the Sheffield Corp. It has a load-weight range of from 25 to 1000 g. and requires only 1 min. for a complete test cycle. Interchangeable vise accessories permit it to be used for testing small precision ground or lapped parts, small diameter wires, very thin materials or material coatings, thin sheet stock, cutting tool



edges and ball bearings. Surface finishes of 40 rms. or less can be inspected, and indentations of 0.0004 in. or smaller can be measured to an accuracy of 0.00008 in. When the instrument is used as a metallurgical microscope, the interchangeable objective lenses provide magnifications of 200 and 400 times.

**For further information circle No. 1448 on literature request card, page 32-B.**

### Meter Cabinets

A new weather-tight case for bearing monitors and other controls containing contact meter-relays has been announced by Assembly Products. The upward-swinging front is gasket sealed and of aluminum construction. Electrical connections are made with weather-tight connectors or conduit. The cabinet protects meter-relays used in moisture laden atmospheres, where steel chips and other materials might damage the instruments, where mild chemicals are present or in outdoor locations exposed to the weather.

**For further information circle No. 1449 on literature request card, page 32-B.**

### Demineralizer

Demineralized soft water, equivalent in ionic purity and softness to triple distilled water, is now available right from the tap with the new Enley

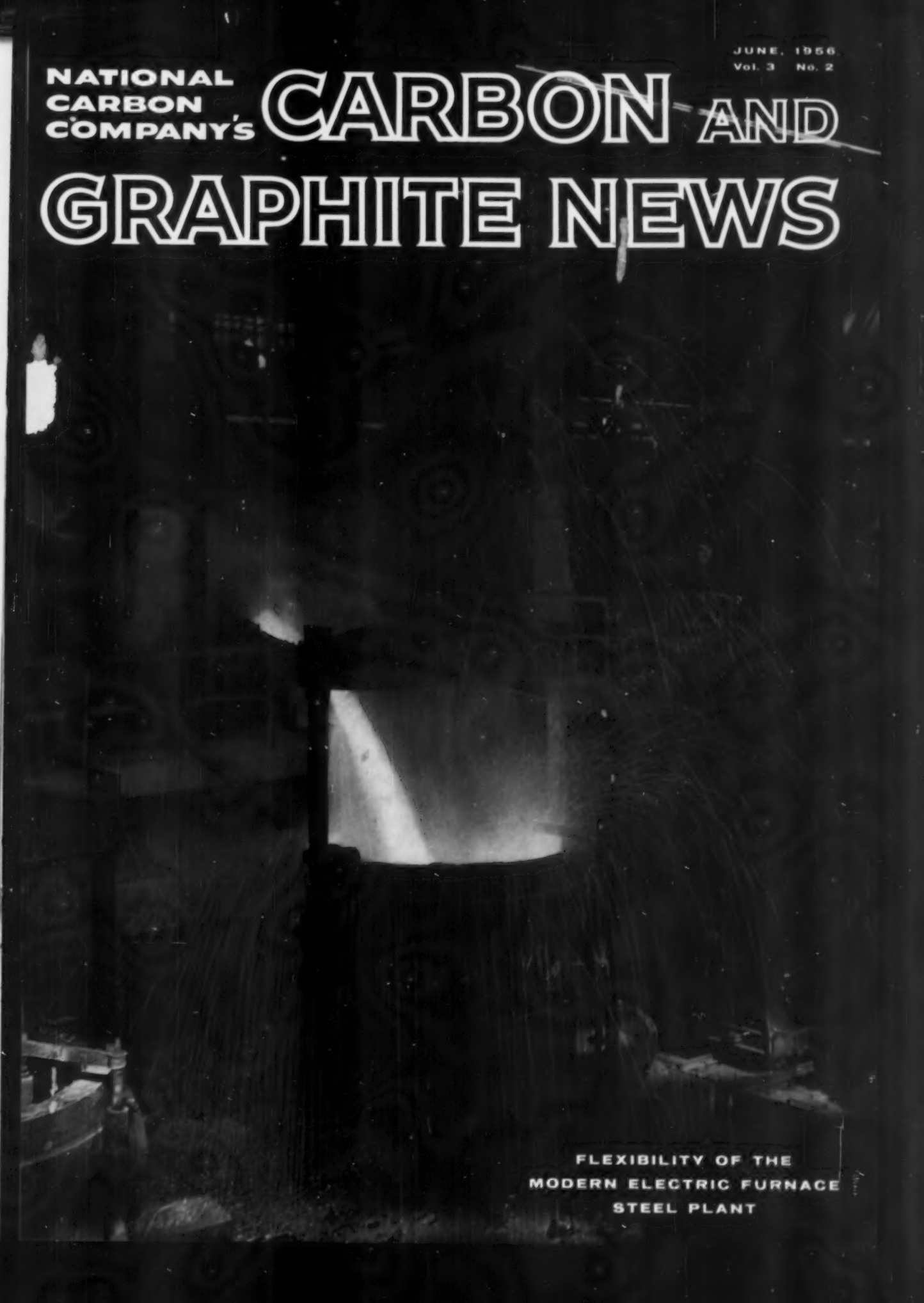


METAL PROGRESS


**NATIONAL  
CARBON  
COMPANY'S**

JUNE, 1956  
Vol. 3 No. 2

# **CARBON AND GRAPHITE NEWS**



**FLEXIBILITY OF THE  
MODERN ELECTRIC FURNACE  
STEEL PLANT**



**Charging** — the electric furnace takes all forms of scrap . . . starts up and shuts down at a moment's notice . . . has low initial and operating costs that yield quickest return on investment dollar.



## **FLEXIBILITY—**

### **99 hours from order to finished product**

**O**N the basis of flexibility alone, the electric arc furnace is a contender for the title of number one tool of modern steel-making. No other method of steel production offers such a wide variety of advantages:

- Ease and speed of start-up and shut-down — adapts instantly to market conditions.
- Maximum latitude in slagging practice — widest variety of product.
- Less space per ton of capacity — lower plant investment.
- Maximum equipment availability — wider distribution of fixed costs.
- Low initial cost, low operating and labor costs — quickest yield on investment dollar.
- Adapts to custom or production runs — handles large and small orders with equal facility.
- Utilization of all types of scrap — lower cost of metallics.
- Top quality of product from stainless grades to carbon steels — improves competitive position.

Growth of electric furnace output during the last ten years — 80% of which is in the field of carbon steel production — points to the many advantages the arc furnace process offers all steelmakers, both in integrated and non-integrated plants.

A typical speciality mill such as Rotary Electric Steel Company in Detroit, Michigan, is actually a closely knit unit, each of whose appendages is highly sensitive to the requirements of its function within the whole. The efficiencies of a manufacturing assembly line are present, but obscured to the inexperienced eye by the magnitude and scope of the operation.

What seems a ponderous, even a leisurely undertaking is really a network of split-second coordinations. It must be so. In the electric furnace steel industry, where the wage bill is a smaller percentage of operating cost than in most industries, lost product — even more than lost man-hours — means big money. No effort is spared to make every melt as perfect as technology and experience can insure.

How can the relatively few electric furnace steel-mills in this country turn out the huge tonnages of finished and semi-finished product that are needed to supply thousands of processors, finishers, fabricators, assembly shops and parts and products manufacturers?



**Melting** — short melt cycles — from 5 to 7 hours — make the electric furnace equal, in output, to an open hearth of several times its nominal capacity. Electrics occupy less space, provide maximum equipment availability . . . wider distribution of fixed costs.

The answer lies in their *flexibility*. Flexibility, not only to operate at a constantly changing percentage of capacity to suit changing market conditions; but the ability, as well, to make that operation serve the most widely divergent and changing requirements of individual customers.

**Let's say you're manager** of a jobbing machine shop in the Detroit area, turning out specialties from stainless, alloy and carbon bar stock. Suddenly, you're up to your belt buckle in orders and nearing the end of your raw materials inventory which is

**Tapping** — electrics assure top quality product from stainless grades to carbon steel . . . improve competitive position through greater adaptability to market conditions . . . offer maximum latitude in slagging practice . . . widest range of product.





**Teeming** — cautiously the high quality, electric furnace steel is poured from ladle to ingot mold. Ceramic hot taps insure a sound ingot with minimum crop loss.

never very large. You can't wait for the mails and for ordinary processing of your inquiry. You are faced with the costly prospect of idle men and machines.

**You call Rotary Electric.** The TIME is 10:00 AM. In a matter of minutes, your order is analyzed by the Order Service Department. First, inventory is checked — nothing available in billet form for your job.

Next, the current melt schedule is investigated — there is a heat of suitable analysis due to be poured the following day with sufficient overage to make a part shipment on your 20-thousand pound order. Now we're getting somewhere! The TIME is 10:07 AM.

**The order is written** in a specially developed business machine order section which types and codes all pertinent information



**Soaking Pit** — Slowly the ingot rises from its bath of fire, properly heat-conditioned for the next operation.

available at this time, from date of order to the data needed for automatic invoice preparation. This formerly time-consuming paper work now requires just nine minutes. The TIME is only 10:16 AM.

**From here on**, the order travels with the steel. The Metallurgical Department processes it, entering instructions from previous orders, including the chemistry of the steel, sequence of operations, special finishes, packaging and shipping instructions. The

TIME is 10:20 AM. Simultaneously, the Production Department makes a note to remove this quantity of steel from inventory and the Scheduling Department arranges for rolling the steel which is coming through early the following morning.

**After careful appraisal** of other mill commitments, every possible readjustment of the schedule is made to accommodate this emergency order. The ingot is poured at 12:05 Midnight. By 8:10 AM of the second



Blooming Mill — the ingot is rolled into a billet...


day, it has left the soaking pit. Quickly it passes through the blooming mill, is pickled, conditioned, reheated and rolled into a bar by 8:00 that evening.

**Annealed and ready for cold finishing**  
32 hours later, the order is inspected and shipped at 1:00 PM of the fourth day — exactly 99 hours from time of the telephone call and starting from scratch. The remainder of the order will be shipped two weeks from date of receipt.

*That's how the flexibility* of the electric furnace steel mill works for its customers to contribute its giant share to the prosperity and comfort of the consuming public.

... which becomes a smaller and smaller square and, finally, in the bar mill, a finished round.





Annealing — Here normalizing temperatures ease the stresses set up by mill-work . . . prepare the finished bar for ultimate machining, forming, forging or welding operations. Once again, flexibility of the electric furnace steel shop proves its ability to deliver the goods — fast!

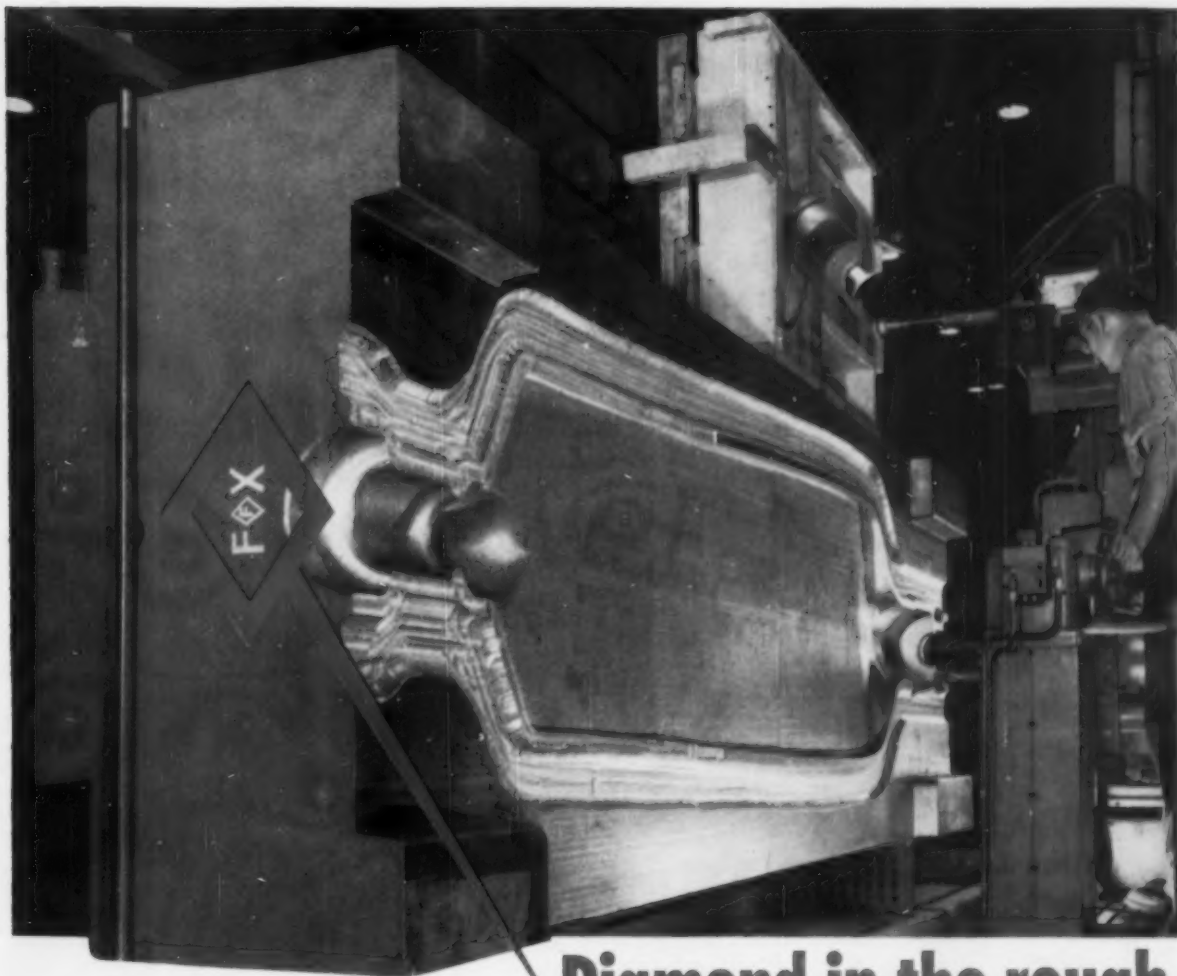
All photographs courtesy of Rotary Electric Steel Company, Detroit, Mich.

*The term "National" is a registered trade-mark of Union Carbide and Carbon Corporation*

**NATIONAL CARBON COMPANY**  
A Division of Union Carbide and Carbon Corporation  
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## Diamond in the rough

This 42,000 pound Finkl FX die nearing completion at the Ladish Co., Cudahy, Wisconsin, will be utilized by that firm in drop forging 1681 pound close tolerance aircraft propeller blades. FX is but one of many Finkl steels available for forging operations, all of which are quality controlled with "built-in" characteristics required for precision production. For the proper die steels to fit your needs, ask your local Finkl representative or write for the Finkl catalog.

When you next consider hot work tooling, die blocks, or forgings, call on Finkl for "impressions that last."



**DIE BLOCKS  
•  
HOT WORK  
STEEL  
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FORGINGS  
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ELECTRIC  
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SAN FRANCISCO • SEATTLE • BIRMINGHAM • KANSAS CITY  
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# **A. Finkl & Sons Co.**

2011 SOUTHPORT AVENUE • CHICAGO 14



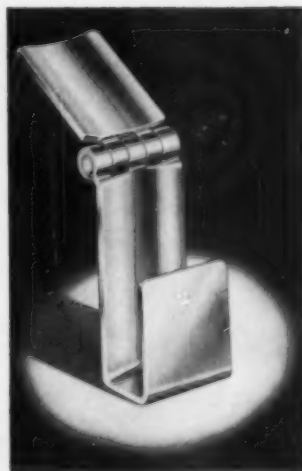
## THE ZIPPO FLIP

## HINGES ON SEYMOUR

Every day, millions of world-famed ZIPPOS repeatedly "flip their lids" to provide bright flames for smokers. To take the punishment of uncounted openings and closings, each lighter is fitted with a smooth-working hinge made of SEYMOUR NICKEL SILVER.

SEYMOUR NICKEL SILVER is a key ingredient in many fine products because it combines beauty and durability. Its lustrous, silvery color is corrosion-resistant and long-lived. Its malleability and ductility are ideal for extensive forming and drawing operations. Its high quality is constant and dependable. For these reasons nickel silver users everywhere say . . .

*"Specify Seymour...you KNOW it's good!"*



# SEYMOUR



**THE SEYMOUR MANUFACTURING COMPANY**

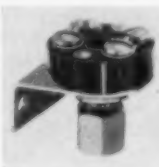
10 Franklin Street, Seymour, Connecticut

"pup", according to Enley Products, Inc. It can be attached to any water outlet. No heat or power is required for operation. It is available in various sizes to provide from 300 to 3000 gal. of water before regeneration and up to 12,000 gal. when used in series. For further information circle No. 1450 on literature request card, page 32-B.

### Miniature Head for Thermocouples

The Marlin Mfg. Corp. has announced a new screw-type connection head for thermocouples, electric heating elements or swaged, magnesium oxide, insulated conductors. Stem sizes adaptable to the new connector head are 1/16, 1/8, 3/16 and 1/4 in. These new sizes will provide a screw-type connection between the small gaged thermocouple wires and the larger gage lead wires. Operating temperatures range up to 500° F.

For further information circle No. 1451 on literature request card, page 32-B.



### Heat Treating Furnaces

The Sentry Co. has announced their size No. 2 model Y electric high speed steel hardening furnace. This furnace



uses the diamond block method of atmosphere control to prevent scaling and decarburization during hardening. For further information circle No. 1452 on literature request card, page 32-B.

### Finishing Aluminum

New applications for cutting and coloring aluminum by bar and liquid buffing compounds have been announced by Hanson-Van Winkle-Munning Co. Two liquid compounds, tripoli 303 and 420, have proven effective in heavy duty cutting in the aluminum pot and pan industry, and liquid tripoli 728 is applicable to the

appliance, storm window and automotive fields. Several tripoli bar compounds meet specific requirements for cutting down aluminum. For cut and color, white compounds are available and where high color is a requisite, aluminum-oxide compounds are recommended.

For further information circle No. 1453 on literature request card, page 32-B.

### Gas Generator

Ipsen Industries has announced an endothermic atmosphere generator featuring automatic dew point control of the base generator gas. By interlocking an automatic dew point controller with the generator, a narrow dew point range is maintained by regulation of the air/gas ratio to the reaction tube. This results in automatic control of the prepared base gas analysis with changing humidity and variations in analysis and pressure of the line gas. This control also minimizes the tendency to over-supply hydrocarbon which would be deposited on the catalyst, thus considerably reducing the number of periodic burn-outs and maintenance.

For further information circle No. 1454 on literature request card, page 32-B.



### Test Chamber

An environmental test chamber with an overhead door has been announced by American Research Corp. The altitude-temperature-humidity chamber may be installed in a location where there was insufficient room to swing a conventional door open. The air cylinder which raises and lowers the door is counterbalanced, so that in case of air failure, the door will not open or close from any posi-

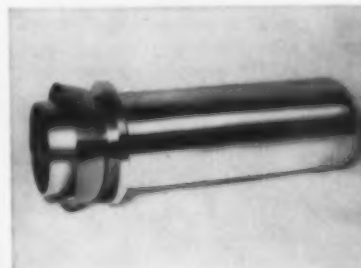


You get  
**Stronger Bonds!**  
**Faster Production!**  
**Less Rejects!**

by

# VACUUM BRAZING

with HI-VAC  
furnaces



Kinetics Corporation uses High Vacuum Equipment Corporation furnaces for brazing assemblies such as the above.

Vacuum brazing lends itself to difficult brazing problems as well as improving the quality of regular brazing work. Brazing cycle can be cut by 1/3. You get bright, homogeneous bonds and highly ductile joints which closely approach the strength of the parent metal. The process is ideal for brazing the new high temperature alloys.

**No Danger of Nitriding!**

**No Fluxes Required!**

**No Purging with Inert Gas!**

Vacuum brazing simplifies production because fewer steps are required. Due to outgassing during the brazing process, the characteristics of the entire structure are markedly improved.

Write to HI-VAC for valuable information on vacuum brazing . . . and on vacuum melting, heat treating, sintering, metallizing, impregnating or crystal growing.

**HIGH VACUUM**  
Equipment Corporation  
349 Lincoln St., Hingham, Mass.

tion. The cabinet is available from 5 to 64 cu. ft. It will simulate altitudes from sea level to 100,000 ft., temperatures from -100 to +500° F., and relative humidity from 20 to 95%. For further information circle No. 1455 on literature request card, page 32-B.

### Metal Identification

A light weight, completely assembled metal testing kit has been announced by Spot-Testers, Inc. The kit

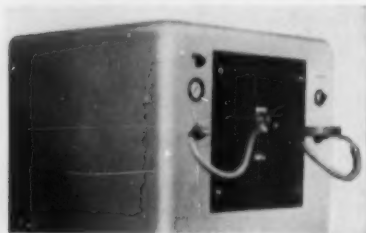


contains the necessary solutions to identify the following metals and their alloys: aluminum, copper, tin, nickel, manganese, phosphorus, iron, steel, molybdenum, cobalt, lead, antimony, zinc, cadmium, Monel, cupronickel, stainless steels, precious and semiprecious metals. It comes with all necessary instructions and a set of metal standards.

For further information circle No. 1456 on literature request card, page 32-B.

### Heating Station

A new remote heating station for use in conjunction with control station and motor generator equipment of either 960, 3000 or 9600 cycles and ranging in power output from 30 to 300 kw. is offered by the High Fre-



quency Heating Div., Lindberg Engineering Co. The unit will provide output flexibility for a wide variety of metal heat treating and fabricating operations. The station has been designed with extra heavy bus bars which are arranged for easy installation and removal of output transformer. Capacitor racks of rugged nonmetallic construction are arranged for convenient removal of capacitors

and accessibility of capacitor connections and provide ample mounting for a total of eight power factor correction capacitors. The station is 40 in. wide by 40 in. deep by 61 in. high. For further information circle No. 1457 on literature request card, page 32-B.

### Ultrasonic Degreasers

The first of a new series of ultrasonic degreasers has been announced by the Industrial and Scientific Products Div. of Curtiss-Wright Corp. The unit is 24 x 10 x 18 in. deep and can accommodate work pieces 8 x 8 x 10 in. Two cleaning stages are featured—vapor degreasing and ultrasonic solvent cleaning. Built-in components consist of pump, filter, solvent spray, heater, thermostats and vapor condenser. Ultrasonic power up to 500 watts at 40 kc. frequency is available over an area of 7 x 9 in. The



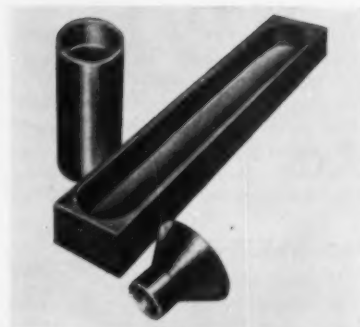
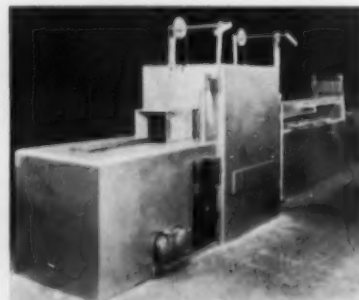
equipment operates from the 110 v., 60 cycle power line, and consumes approximately 2500 watts maximum.

For further information circle No. 1458 on literature request card, page 32-B.

### Brazing Furnace

Waltz Furnace Co. has announced a continuous brazing and sintering furnace. The cooling chamber at the back is 2½ times the length of the heating chamber. There are gas curtains at the entrance door and the exit end of the cooling chamber. The entrance end has a preheating hood in front of the actual door to the furnace. The heating chamber is 12 in. wide by 8 in. high by 48 in. long. The furnace is heated to 2300° F. by eight Globar units mounted vertically, four on each side. The maximum input is 35 k.w.

For further information circle No. 1459 on literature request card, page 32-B.



### Laboratory Equipment

United Carbon Products Co. has announced preformed high-purity graphite crucibles, boats and funnels for research and development. They are used in vacuum fusion analysis, manufacture of transistors and in many special metallurgical studies and applications. They are machined to close tolerances and produced in a variety of standard sizes.

For further information circle No. 1460 on literature request card, page 32-B.

### Blower

General Blower Co. has announced a new blower capable of delivering 2650 cfm. It is designed for oil burner operation. The blower lends itself to multiple burner and multiple outlet

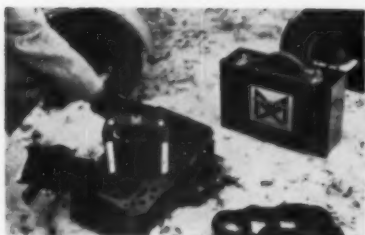


applications. It may be supplied with wheels made from aluminum, mild steel or stainless steel. Performance chart on the unit shows a relatively flat static pressure curve.

For further information circle No. 1461 on literature request card, page 32-B.

### Inspection

A new magnetic particle inspection device that requires no electrical power has just been announced by Magnaflux Corp. Since electric arcing is impossible, YM-5 makes practical the inspection of critical parts or welds in hazardous areas such as refineries, chemical plants, and explo-

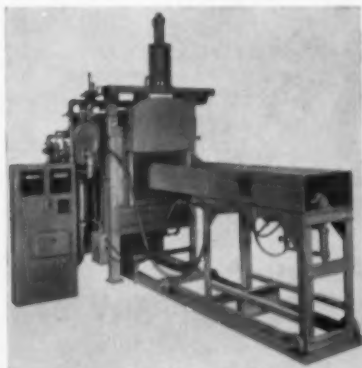


sives. The kit comes complete with a metal storage and carrying case, and total kit weight is only 22 lb. The permanent magnet elements are alnico and the magnetic pull is over 40 lb. on a flat surface.

For further information circle No. 1741 on literature request card, page 32-B.

### Aluminum Melting

Eclipse Fuel Engineering Co. has announced a new aluminum melting furnace of nontilting type with automatic loading tray. Burners fire vertically from the furnace roof. The



roof hangs from the furnace frame and does not bear on the side walls; thus the sidewalls can be rebricked without disturbing the arch. A packaged control center is furnished which includes two indicating controllers, one for each burner.

For further information circle No. 1742 on literature request card, page 32-B.

### Finishing

A new eight-door stationary-fixture finishing machine designed primarily for coloring of aluminum castings has been announced by Roto-Finish Co. The new machine has a door on each flat of a single compartment cylinder. Fixture pads are attached to the octagon side walls of the compartment just inside the door opening. Fixtures are in the form of grids, which fit the attached pads. Processing compartments vary in size up to 48 in. long and 42 in. in diameter. Most suitable size is a compartment 32 in. long and 42 in. in diameter. The latter size, used for coloring



# TYPLEX



**AIR HARDENING  
HOT WORK  
DIE STEEL**  
CHROMIUM NICKEL  
MOLYBDENUM TYPE

For Forging ALUMINUM - COPPER - STEEL

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For forging ALUMINUM, COPPER and STEEL. Reports from enthusiastic users claim as much as 30% INCREASED PRODUCTION OVER ORDINARY TYPES OF HOT WORK STEELS. A large Midwest Forge concern has reported producing 134,000 PIECES WITH 30% OF DIE LIFE REMAINING, as compared to average of 66,000 pieces per die block, and with 50% LESS DOWN-TIME FOR REPAIRS.

For Insert dies for use in  
 Board Hammers—Hot  
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● Upsetters—Hot  
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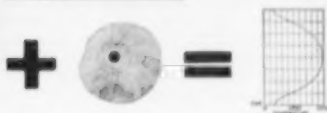
**NOW** compact, dependable,  
economical, guaranteed

**Completely AUTOMATIC PROCESS CONTROL  
of TIME-TEMPERATURE CYCLE**



through off-on or proportioning, high limit or stepless control action with secondary switching provisions!

**Gardsman** Model JG Series  
Versatile, Indicating, Pyrometric  
**PROGRAM CONTROLLERS**



- Maintains extremely accurate time-temperature relation through broad range.
- Automatically repeats identical cycle for thousands of operations. By replacing cam the same instruments

- may be used for different time-temperature programs.
- Works with choice of 4 types of basic control.
- Requires no warm-up, tuning; less maintenance.

See how this new instrument can help your work. Write for Model JG Series and data on our complete line. Also available, 32-page thermocouple and accessory bulletin.

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CHICAGO 41, ILLINOIS

**WEST** Instrument  
CORPORATION  
SALES OFFICES IN PRINCIPAL CITIES.

*"We like this designed-in-service"*

says this  
**"HOT  
ROD"**

user



At the Plant Of General Riveters, Inc., in Buffalo, N. Y., this electric furnace, with Inconel muffle and Norton CRYSTOLON® heating elements, is used in heat treating, to bring out the magnetic properties of Vicalloy metal, a component of hysterises type clutches for airborne equipment. Designed and built by the Edward G. Pierson Co. of Grand Island, N. Y., the furnace has given maintenance-free service since its installation over two years ago. The original "Hot Rods" installed are still delivering top performance.

#### **Proved "Hot Rod" Advantages**

You save in element costs, because you use far less "Hot Rods." Many plants report they outlast other non-metallic heating elements *up to 3 to 1!* This also means less maintenance time spent in changing elements and voltage taps. Also, "Hot Rods" heat more uniformly, due to their slow, evenly matched rate of resistance increase. This helps pro-

tect product quality and maintain a smooth production flow.

For further facts on how "Hot Rods" can help improve your furnace operations and cut costs, send for booklet, "Norton Heating Elements." NORTON COMPANY, Refractories Division, 325 New Bond Street, Worcester 6, Mass.

\*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries

**General riveters, inc.**

781 HERTEL AVE., BUFFALO 7, N. Y.  
DE 4-6483 TW 4-5123

January 6, 1956

Mr. Warren Davenport  
Norton Company  
Worcester 6, Mass.

Dear Mr. Davenport:

We are happy to inform you that Norton CRYSTOLON heating elements are giving us excellent service. In an electric furnace built for us by the Edward G. Pierson Co. they have helped eliminate the maintenance we have always experienced with other electric and gas furnaces.

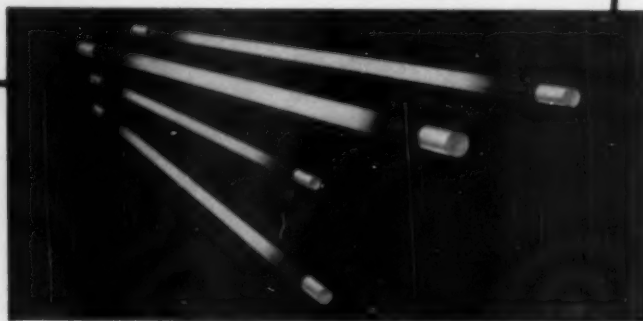
These Norton "Hot Rods" have already lasted over 11,000 hours in operation without a single failure or replacement. The spare elements bought nearly two years ago with the furnace have never been used.

This is the kind of designed-in service we like.

Very truly yours,  
GENERAL RIVETERS, INC.

*T. H. Speller*  
T. H. Speller,  
President

THS/ljk



CRYSTOLON heating elements, or "Hot Rods" are a typical Norton R — an expertly engineered refractory prescription for greater efficiency and economy in electric furnace and kiln operation. Made of self-bonded silicon carbide, each rod has a central hot zone and cold ends. Aluminum-sprayed tips and metal-impregnated ends minimize resistance and power loss. Available in standard sizes and interchangeable with your present rods.

**NORTON**

**REFRATORIES**

Engineered... **R**... Prescribed

*Making better products...  
to make your products better*



aluminum castings with steel balls, uses a  $7\frac{1}{2}$  hp. drive equipped with automatic reversing electric controls. For further information circle No. 1743 on literature request card, page 32-B.

### Testing Equipment

Strain cycles occurring within six different levels can be totaled with a strain cycle counter announced by Franklin Electronics, Inc. This new recording apparatus incorporates a self-balancing strain gage bridge, servo amplifier and counters to register strain cycles as low as 500 psi. Mechanical loading and fatigue data occurring in automotive equipment, aircraft, ships, railroad rolling



stock and structures such as buildings, bridges and trestles can be collected under actual operating conditions.

For further information circle No. 1744 on literature request card, page 32-B.

### Recorder-Controller

A self-balance recorder-controller for application in a wide range of industrial process operations has been announced by Robertshaw-Fulton Controls Co. The new instrument was designed primarily for the measurement and control of levels of liquids, granular solids, interface and other conducting or nonconducting substances. Because it is of the capacitance type, the new instrument may be used for other process variables, such as moisture content or composition, which cause a direct change in dielectric constant. Electrical and pneumatic control forms can be incorporated within the single housing.

For further information circle No. 1745 on literature request card, page 32-B.

### Burnishing Barrel

A new portable Mercil burnishing barrel has been announced by Hanson-Van Winkle-Munning Co. The barrel is made of Plexiglas and is 8 in. in diameter and 8 in. long. It is powered

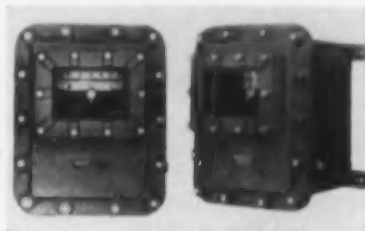
by a  $1/18$  hp., 5000 rpm., 115 v. motor. The barrel can handle 5 to 10 lb. of work and 20 to 25 lb. of balls.

For further information circle No. 1746 on literature request card, page 32-B.

### Pyrometer Housings

A standard explosion proof housing for pyrometers has been announced by West Instrument Corp. It is designed to meet U.L. specifications for Class 1 Group D hazardous locations. Its cast iron body is bolstered at test-shown stress points and holds a  $1\frac{1}{4}$  in. thick block of clear safety glass. The large area of this glass,  $4 \times 6$  in. permits constant view of the scale and pilot lights. An external temperature setting knob is provided so the cover does not have to be removed to change the control point.

For further information circle No. 1747 on literature request card, page 32-B.



KENTRALL Hardness Tester

## MAKES BOTH Superficial & Regular Tests

Thoroughly proven in the field over the past two years, the KENTRALL makes all Superficial Rockwell tests (15, 30 and 45 kg. loads), as well as all Regular Rockwell tests (60, 100 and 150 kg. loads).

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**Torsion  
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Model CT-2  
Price \$680



**HANDLE  
EXTRA-TOUGH  
THERMOCOUPLE  
WIRE JOBS WITH  
T-E "Ceramo"**

"Ceramo" does the jobs too tough for ordinary thermocouple wire. "Ceramo" construction—thermocouple elements and inert metallic oxide insulation encased in a seamless metal sheath—has resulted in a wire of unusual durability.

Basically rigid, "Ceramo" can be bent on an extremely small radius without shorting or grounding. Encased "Ceramo" thermocouples last longer and respond faster than conventional types. Available in all standard calibrations. Depending on conductors and sheath material, "Ceramo" can be used up to 3000°F. Sheath for T/C wires—Stainless Steels, Inconel, tantalum and platinum. For T/C extensions—copper-nickel alloy, plain or galvanized cold-drawn steel.

WRITE FOR  
BULLETIN 31-300-H.

**Thermo Electric Co., Inc.**  
SADDLE BROOK, NEW JERSEY  
In Canada—THERMO ELECTRIC (Canada) Ltd., Brampton, Ont.



**best on every point**  
*...and among high speed steels*  
**the top performer is REX**

To leap the hurdle of competition, a product needs performance born of quality. And Crucible's REX® high speed steel has it — in accurate size . . . sound uniform structure . . . dependable response to heat treatment . . . optimum tool performance.

Now, thanks to improved manufacturing techniques, REX is even better — more uniform. Put it to work on your next job, and you'll quickly know why REX is today, as it has always been — *the standard by which all other high speed steels are compared.*

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**CRUCIBLE**

first name in special purpose steels

**Crucible Steel Company of America**

Canadian Distributor — Railway & Power Engineering Corp., Ltd.

# APPLICATION and EQUIPMENT

## new literature

### 1464. Alloy Castings

Bulletin 3150-G on castings for heat, corrosion, abrasion resistance. *Duraloy*

### 1465. Alloy Castings

8-page bulletin on alloy castings for heat treating. *Ohio Steel Foundry*

### 1466. Alloy Castings

Data folders on two types of alloy steel castings. Composition, properties, hardenability bands, uses. *Unitcast*

### 1467. Alloy Steel

Data book on the selection of the proper alloy steel grades for each manufacturer's needs. *Wheelock, Lovejoy*

### 1468. Alloy Steel

Comparative tables of SAE and AISI standard steels and tentative standard steels. *Babcock & Wilcox*

### 1469. Alloy Steel

14-page bulletin on two chromium-nickel alloy steels. Properties, working instructions, heat treatment, recommended uses. *Carpenter Steel*

### 1470. Alloy Steel

207-page book gives more than 50 complete case histories of alloy steel usage. *Climax Molybdenum*

### 1471. Alloy Steel

40-page book on applications of heat treated, special alloy steel. *Jones & Laughlin*

### 1472. Alloy Steel

16-page book on type 9115 low-alloy high-strength steel. Properties, fabrication, welding. *Great Lakes Steel*

### 1473. Alloy Steel

32-page book on abrasion resisting steel. Properties, fabricating characteristics, uses. *U. S. Steel*

### 1474. Aluminum Die Castings

Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

### 1475. Aluminum Extrusions

Data on commercial aluminum extrusions. *Superior Industries*

### 1476. Aluminum Heat Treating

8-page Bulletin 5912 on solution heat treating, annealing, stabilizing and aging of aluminum. *General Electric*

### 1477. Annealing Copper

Reprint 55-D on how to anneal copper tubing. Furnaces, contamination control, brightening. *Surface Combustion*

### 1478. Atmosphere Furnace

Bulletin on controlled atmosphere furnace. *Industrial Heating Equipment*

### 1479. Annealing Furnaces

8-page illustrated booklet on continuous annealing furnaces. Schematic diagrams, photographs, and actual production data. *Drever*

### 1480. Atmosphere Furnace

Information on mechanized batch-type atmosphere furnaces for gas cyaniding,

gas carburizing, clean hardening or carbon restoration. *Dow Furnace*

### 1481. Atmospheres

12-page booklet on design and use of special atmospheres for industrial furnaces. *Continental Industrial Engineers*

### 1482. Atmospheres

12-page bulletin on use of protective atmospheres to prevent deterioration of metals during various heat treating processes. *General Electric*

### 1483. Atmospheres

Bulletin 439 on exothermic atmosphere generators for converting natural gas, manufactured gas, propane or butane. *W. S. Rockwell*

### 1484. Bearings

20 data sheets give special properties and case histories for new Rulon oil-free bearing material. *Dixon Corp.*

### 1485. Beryllium Copper

12-page Bulletin 6 on advantages of beryllium copper and suggestions for ordering, including alloys, condition and temper, tolerances. *Penn Precision Products*

### 1486. Beryllium Copper Springs

New 4-page bulletin on use and advantages of beryllium copper in new vibration damping device. *Beryllium Corp.*

### 1487. Bimetal Applications

New 44-page booklet, "Successful Applications of Thermostatic Bimetal" contains uses, formulas, calculations. *W. M. Chace*

### 1488. Black Oxide Coatings

8-page booklet on black oxide coatings for steel, stainless steel and copper alloys. *Du-Lite*

### 1489. Blast Cleaning

Bulletin 227 on airless blast cleaning machine. Features of construction, sizes, how it operates. *Pangborn*

### 1490. Brazing

New bulletin on low-temperature brazing and its uses. *Handy and Harman*

### 1491. Burner

Bulletin 214 on dual-fuel burner for ovens, kilns, driers, forge furnaces, heat treating and malleabilizing furnaces. *North American Mfg.*

### 1492. Burners

8-page bulletin on ribbon gas burners for continuous heat processing. *Selas Corp.*

### 1493. Calibrating Machine

Bulletin 115 on calibrating system for accurate measurement of mechanical forces. *Morehouse Machine*

### 1494. Carbides

84-page catalog of sintered carbides, hot pressed carbides, cutting tools, drawing dies, wear resistant parts. *Metal Carbides*

### 1495. Carbon and Graphite

30-page catalog on carbon and graphite applications in metallurgical, electrical, chemical, process fields. *National Carbon*

### 1496. Carbon Control

Bulletin C-22 and reprint on Carbotronik for automatic control of carbon potential of atmospheres. *Ipsen*

### 1497. Carburizing

16-page booklet on gas-carburizing processes and equipment. Discussion of suspended carburization, carbon restoration. *Surface Combustion*

### 1498. Carburizing

Data folder on Aerocarb E and W water-soluble compounds for liquid carburizing. Case depth vs time curves. Percent carbon and nitrogen penetration curves. *American Cyanamid*

### 1463. Steels

64-page pocket-sized handbook gives analysis and heat treatment data for Crucible high speed, hot work, die casting, plastic molding, air, oil, water hardening, and stainless steels and welding electrodes. *SAE*



AISI standard carbon steels, alloy steels TS steels, H steels and boron steels are also included. Further useful data consists of temperature conversion tables, standard wire gages in decimal equivalents, hardness conversion charts and fraction-decimal equivalents. *Crucible Steel Co.*

### 1499. Casehardening

32-page booklet on casehardening of steel by nitriding. *Armour Ammonia Div.*

### 1500. Cemented Carbides

20-page booklet illustrates and describes all styles of standard blanks, boring tools, roll turning and milling cutter blanks, throw-away inserts and others. Grade selection chart. *Firth-Loach Metals, Inc.*

### 1501. Chromate Finishing

File on chromate conversion coatings for prevention of corrosion and paint-base treatment of nonferrous metals. *Allied Research Products*



**"Quality in our heat treating  
calls for  
GULF SUPER-QUENCH  
in our tanks"**

**says Mr. Lloyd Mattson, owner,  
Quality Steel Treating Co.  
of Anderson, Indiana.**

**"Q**UALITY is not just a name with us. We carry it through every operation in the heat treatment of tools, dies, and precision parts for aircraft and automotive equipment," says Mr. Mattson. "And much of the credit for our quality heat treating belongs to Gulf Super-Quench which delivers deep, uniform hardness without cracking or distortion."

The superior quenching power of Gulf Super-Quench assures deeper, more uniform hardening even on steels of variable hardenability and on parts with variable sections or odd shapes. This

results in fewer rejects and a substantial saving in money.

Another important reason for Gulf Super-Quench's high rank among heat treating concerns is its ability to retain its fast dual quenching power indefinitely with only normal make-up. There is no need for additive replenishment.

Perhaps a Gulf Sales Engineer can help you find opportunities to use Gulf Super-Quench profitably in your shop. Consult the telephone directory for the number of your local Gulf office.

**THE FINEST PETROLEUM PRODUCTS FOR ALL YOUR NEEDS**

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1822 Gulf Building



**GULF REFINING COMPANY**  
Pittsburgh 30, Pa.

**1502. Cleaning**

Folder on di-phase cleaning gives equipment, construction features, spray and blow-off features, heating systems. *Solventol*

**1503. Cleaning Aluminum**

12-page bulletin on cleaning process for preparing aluminum and magnesium for welding. *Northwest Chemical*

**1504. Cleaning Compound**

Bulletin B-6 on water displacing compound for producing unspotted, dry surfaces. *Apothecaries Hall*

**1505. Cold Rolled Steels**

32-page booklet on stainless, alloy and carbon spring steels, and other specialties. Melting, temper, finishes. *Crucible*

**1506. Cold Treatment**

8-page folder describes various models of industrial freezers and gives their ranges. Applications. *Webber Mfg. Co.*

**1507. Controllers**

46-page Bulletin 1120 on pneumatic control and transmission systems. Pneumatic controllers and how they work. *Mim. capolis-Honeywell*

**1508. Copper Alloys**

40-page book on eleven copper alloys. Properties, cleaning, annealing. *Seymour*

**1509. Corrosion Inhibition**

16-page booklet on sodium nitrite as a corrosion inhibitor in processing metals, water circulation systems, petroleum industry and others. *Solvay Process Div.*

**1510. Corrosion Prevention**

Full technical details on Turcoat 4178 aluminum conversion coating that stops corrosion of aluminum, improves paint adhesion and provides an ornamental finish. *Turco Products*

**1511. Corrosion Protection**

New 16-page bulletin on corrosion proof construction materials includes sections on corrosion proof cements, tank linings, protective coatings and others. *Atlas Mineral Products*

**1512. Cut-Off Wheels**

Folder gives data, operating suggestions and grade recommendations of cut-off wheels. *Manhattan Rubber Div.*

**1513. Cutting Compound**

Bulletin No. 137 on cutting compound outlines major features. *Magnus Chemical Co., Lubricants Div.*

**1514. Cutting Oil**

Facts on more efficient and economical plant operation through use of right lubricants described in "Metal Cutting Fluids" booklet. *Cities Service*

**1515. Cutting Oil**

Bulletin 963 on transparent cutting oil which is designed for use on a wide variety of steels. *Sun Oil Co.*

**1516. Cutting Tools**

36-page booklet analyzes and compares carbon, high speed, cast alloy and carbide tool materials. *Allegheny Ludlum*

**1517. Cutting Tools**

New 4-page bulletin includes physical and mechanical properties and results of a series of machining trials. *Stupakoff Div., Carborundum Co.*

**1518. Decarburization**

8-page booklet on effects of decarburization on tool steels tells what it is and what can be done about it. *Carpenter Steel*

**1519. Degreasing**

34-page booklet on vapor degreasing. Design, installation, operation and maintenance of equipment. *Circo Equipment*

**1520. Descaling**

8-page bulletin on sodium hydride de-

scaling process for ferrous and nonferrous metals. *DuPont*

**1521. Descaling**

Brochure on sodium hydride descaling, its uses, advantages, typical reactions and necessary equipment. *Ethyl Corp.*

**1522. Dew-Point Recorder**

Bulletin 11-11 on dew-point systems for recording or controlling. *Foxboro*

**1523. Die Casting**

24-page catalog describes die casting process, machines and products. Instructions on installation of die casting machines, designing and fabricating dies. *DCMT Diecasting Machines*

**1524. Die Casting**

New illustrated catalog on complete line of die casting machines. *Kur Machine*

**1525. Die Casting Machines**

New bulletin on model 400-N die casting machine for aluminum, brass, magnesium, zinc, lead and tin alloys. *Cleveland Automatic Machine Co.*

**1526. Ductile Iron**

New 28-page bulletin gives advantages and applications of ductile iron. Properties. *International Nickel Co.*

**1527. Dynamometers**

4-page folder on precision dynamometers for measuring traction, tension or weight. Capacities from 0 to 500 lb. to 0 to 100,000 lb. *W. C. Dillon*

**1528. Electric Furnaces**

Brochure on electric heat treating, melting, metallurgical tube, research and sintering furnaces. *Pereny Equipment*

**1529. Electric Furnaces**

Bulletin on electric heat treating fur-

naces gives summary of progress in furnace developments. *Holcroft*

**1530. Electric Furnaces**

12-page booklet on research facilities for building and operating electric furnaces. *Electric Furnace Co.*

**1531. Electric Furnaces**

Catalog of electric furnaces and ovens for hardening, tempering, annealing, drawing, drying, baking, enameling. *Cooley Electric Mfg.*

**1532. Electrolytic Metals**

New 4-page folder on analysis and specifications of electrolytic chromium and manganese. Uses and properties. *Electro Metallurgical Co.*

**1533. Electroplating**

Data sheet describes jet plater complete electroplating plant. *Hart Messing Corp.*

**1534. Electron Microscope**

20-page booklet on special features and uses of electron microscope. *RCA*

**1535. Expanded Metal**

4-page folder on small-mesh expanded metal. Weights, dimensions for various gages and strands. *Penn Metal Co.*

**1536. Extensometer**

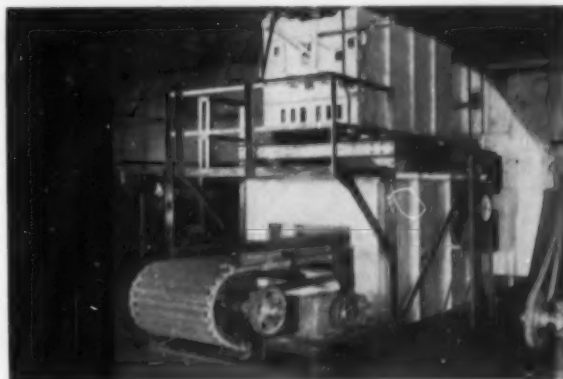
8-page bulletin on extensometers for sheet metal and wire, compressometers, defectometers and other accessories. *Baldwin-Lima-Hamilton*

**1537. Extrusions**

New 20-page booklet on extruded rod and bar stock in beryllium copper, beryllium aluminum and beryllium nickel alloys, beryllium metal and oxide. *Beryllium Corp.*

**1538. Fabrication**

Booklet on welded steel heavy fabri-



## carl mayer Hi-Temp, Recirculating Type HEAT TREAT FURNACES

effect large savings in drawing, tempering, ageing, and heat treating of such products as bearings, billets, springs, screws, tools, gears, etc. in steel or aluminum. Continuous operation at temperatures up to 1200° F. Temperature uniformity guaranteed! Gas, oil, or electric fired.

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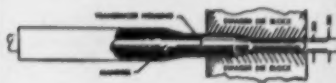
OTHER PRODUCTS: Core & Mold Ovens • Rod Bakers • Paint and Ceramic Drying Ovens • Special Processing Equipment & Accessories

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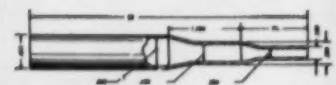
### SWAGING TRANSDUCER HOUSING



First pass  
Dimensions held to .001 tolerance.



Second pass



Finishing Housing

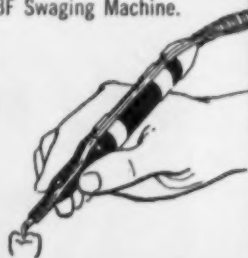


Model 3F

## How **SWAGING** cuts costs **80%** on Transducer Housing

The Cavitron Ultrasonic Dental Unit provides a marvelous new method for preparing cavities without noise, vibration and heat which contribute so greatly to dental pain and discomfort. Internal dimensions of the transducer housing are critical. A mating cap requires the outside diameter to be rigidly held as well. This housing was formerly machined in two parts and silver brazed together. Now, it is made in one piece from tube stock in 2 passes on a Fenn Model 3F Swaging Machine.

**RESULT** — Cavitron has not only reduced cost of the Transducer Housing 75% to 80% but now has a simplified one-piece housing that is stronger, easier to make and with a smooth, bright surface resulting from swaging which requires no additional finishing. Write for catalog and full information.



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may have important advantages and savings in the manufacture of your products. Fenn engineers are at your service.



Precision Rolling Mills



Turks Heads



Wire Shaping Mills



Swaging Machines



Wire and Tube Drawing Machines

**FENN MANUFACTURING COMPANY, 502 Fenn Road, Newington, Connecticut**

cation pictures and describes how various products are made. *R. C. Mahon*

### 1539. Fasteners

New catalog No. 58 shows cold forged specialties, special rivets, screws and such secondary operations as reheading, special threading, pointing, turning, swaging. *Hassall*

### 1540. Fasteners

New 24-page booklet covers technique of manufacture, proper installation, bibliography. *National Machine Products Co.*

### 1541. Filters

32-page booklet on filters, mixers, pumps and tanks for liquid processing. *Alsop Engineering*

### 1542. Finishing Barrel

Data on new heavy duty barrel for finishing stamped, forged and machined, cast parts. *Lord Chemical*

### 1543. Flame Machining

New booklet on precision flame machining of large sprockets and gears. *Seaman-Andwall Corp.*

### 1544. Forging

18-page bulletin 75-C on high speed forging presses describes and illustrates various features. *Ajax Mfg. Co.*

### 1545. Forging Machinery

32-page book No. 165 on design of dies for upsetting forging machines also includes machines, representative parts, tables of decimal equivalents and areas of circles. *Ajax Mfg. Co.*

### 1546. Forgings

94-page book on die blocks and heavy-duty forgings. 20 pages of tables. *A. Finkl & Sons*

### 1547. Forgings

New bulletin on forge steel making, open die forging, machining, heat treating and finishing. *National Forge*

### 1548. Forgings

Folder on large forgings of carbon and alloy steel. *Struthers Wells Corp., Titusville Forge Div.*

### 1549. Forgings

6-page brochure on cored forgings of aluminum and other nonferrous metals. Advantages. *Weatherhead Co.*

### 1550. Formed Shapes

New 26-page catalog No. 1555 contains drawings and dimensions of more than 100 shapes. *Roll Formed Products Co.*

### 1551. Furnace Belts

New 42-page booklet on alloy steel belts for continuous high-temperature furnaces. *Wickwire Spencer*

### 1552. Furnace Belts

44-page catalog describes metal belts for quenching, tempering, carburizing and other applications. *Ashworth Bros.*

### 1553. Furnace Charging

12-page brochure on eight models of charging machines for heating and melting furnaces. *Salem-Brosius*

### 1554. Furnace Fixtures

16-page catalog on baskets, trays, fixtures and carburizing boxes for heat treating. 66 designs. *Stanwood Corp.*

### 1555. Furnaces

40-page book describes gas and electric furnaces and applications. Four basic types of atmospheres. Glossary of heat treating terms. *Westinghouse*

### 1556. Furnaces

Folder describes complete set up for heat treatment of small tools, including draw furnace, quench tank and high temperature furnace. *Waltz Furnace*

### 1557. Furnaces

Bulletin on controlled atmosphere fur-

nales and generating assemblies for annealing, brazing, hardening, sintering, soldering. Sargeant & Wilbur, Inc.

#### 1558. Furnaces

Folder shows various heat treating and forging furnaces made at Detroit plant. Pacific Industrial Furnace

#### 1559. Furnaces

8-page bulletin HD 341R on multi-range convection furnaces. Designs and temperature ranges. Hevi Duty

#### 1560. Furnaces

Brochures on pot furnaces, nitriding, austempering, and martempering and salt baths. A. F. Holden

#### 1561. Furnaces

Bulletin on electric heat treating furnaces describes five series and accessories. Lucifer Furnaces

#### 1562. Furnaces, Heat Treating

32-page catalog on high-speed gas furnaces for heat treating carbon and alloy steels; also pot furnaces for salt and lead hardening. Charles A. Hones

#### 1563. Galvanometers

12-page bulletin 320 on galvanometers to meet varying conditions. Rubicon Company

#### 1564. Gas Analysis

Data on positive, nondispersion-type infrared analyzers for laboratory and industry. Minneapolis-Honeywell

#### 1565. Gas Analysis

New Bulletin No. 306 on gas analysis kits for on-the-job determinations of carbon dioxide or oxygen in flue gases, furnace atmospheres and other gas mixtures. Burrell

#### 1566. Gold Plating

Folder on salts for bright gold plating. Equipment needed. Sel-Rez.

#### 1567. Graphitic Tool Steel

48-page booklet on heat treating data, properties and 46 specific applications of graphitic tool steel. Timken

#### 1568. Grinding Machines

Folder on grinders tabulates horsepower, wheel size, speeds and sizes for various models. Grinding and Polishing Machinery Corp.

#### 1569. Grinding Wheels

New 36-page booklet on mounted wheels gives maximum operating speeds in 8 tables. Rules for safe and efficient operation. Grinding Wheel Institute

#### 1570. Hardness Numbers

Pocket-size table of Brinell hardness numbers incorporating other tabular information. Steel City Testing

#### 1571. Hardness Tester

Bulletin on hardness tester for all regular and superficial Rockwell tests. Kent Cliff Div., Torsion Balance Co.

#### 1572. Hardness Tester

New bulletin on Wolpert-Gries Micro-Reflex hardness tester for loads from 10 to 3000 g. Gries Industries, Inc.

#### 1573. Hardness Tester

Data on hardness testing scleroscope with equivalent Brinell and Rockwell C numbers. Shore Instrument

#### 1574. Hardness Tester

20-page book on hardness testing by Rockwell method. Clark Instrument

#### 1575. Hardness Tester

Data on portable tester with five most widely used hardness scales. Co. for Technical Progress

#### 1576. Hardness Tester

Bulletin on Impresor portable hardness tester for aluminum, aluminum alloys and soft metals. Barber-Colman

#### 1577. Hardness Testers

Catalog of testers for normal hardness, superficial testing, accessory and special testing and micro and macro hardness testing. Wilson Mechanical Instrument

#### 1578. Heat Exchanger

Bulletin 124 on heat exchanger for cooling water, oil and other liquids and gases in many industries. Niagara Blower

#### 1579. Heat Resistant Alloy

10-page article on how to get best service out of standard grades of heat resisting alloys by proper selection. Rolled Alloys

#### 1580. Heat Treating

20-page catalog on the Homocarb method with Microcarb atmosphere control for heat treatment of steel. Leeds & Northrup

#### 1581. Heat Treating

8-page article on heat treatments for ductile iron. Process for developing ten-

### 1462. Product File

More than 30 new product developments, more than 700 important and interesting booklets, bulletins and engineering data sheets are presented in a 16-page-file reference in *Application and Equipment News*. Reprinting all the hundreds of product literature items that have appeared in *Metal Progress* during the second quarter of 1956, this handy summary of what's new in metals, design applications, processing, fabrication and equipment makes an ideal file reference for use throughout the year.

side strength from 60,000 to 150,000 psi. and elongation to 25%. International Nickel Co.

#### 1582. Heat Treating Ammonia

24-page "Guide for Use of Anhydrous Ammonia" describes heat treating and other metallurgical uses. Nitrogen Div.

#### 1583. Heat Treating Fixtures

24-page catalog on heat and corrosion-resistant equipment for heat treating and chemical processing. 30 classifications of equipment. Pressed Steel

#### 1584. Heat Treating Fixtures

12-page bulletin on wire mesh baskets for heat treating and plating. Wiretex

#### 1585. Heat Treating Fixtures

32-page Catalog G-10 covers heat and corrosion resistant fabricated alloy products. Includes furnace muffles, trays, fixtures, retorts, pit-type furnace equipment, salt bath equipment, pickling and plating equipment. Rolock, Inc.

#### 1586. Heat Treating Pots

Bulletin 110 gives data on sizes and shapes of cast nickel-chromium solution pots. Fahrloy

#### 1587. Heating Elements

24-page booklet on elements for electric furnaces and kilns includes technical data, uses, physical and electrical specifications. Norton

#### 1588. Heating Elements

24-page Bulletin H on electric heating elements. Includes extensive tabular data on physical and electrical specifications for various sizes. Globar Div.

#### 1589. High-Alloy Fabrication

4-page bulletin on high-alloy assemblies for chemical, petroleum, food, petrochemical, pharmaceutical and other process industries. General Alloys

#### 1590. High-Frequency Welding

Report on making aluminum tubing by high-frequency resistance heat method at Aluminum Co. of Canada. New Rochelle Tool

#### 1591. High-Strength Bronze

12-page booklet on tinic bronzes with high strength, high hardness, good machinability, age hardenability, corrosion resistance. Chase Brass

#### 1592. High-Strength Steel

48-page book on T-1 steel, its properties and applications. U.S. Steel

#### 1593. High-Strength Steel

66-page catalog on Mayari®R steel. Applications which take advantage of its wear and corrosion resistance. Bethlehem Steel

#### 1594. High-Temperature Belts

Bulletin T-241 on belts of high-temperature alloy for heat treat furnaces. Electro-Alloys

#### 1595. High-Temperature Lubrication

Bulletin on colloidal graphite lubrication of kiln cars, oven conveyors and forging dies. Acheson Colloids

#### 1596. High-Temperature Tubing

Bulletin TDC-163A on analysis, properties, creep and rupture data for various tubing alloys for high temperature service. Babcock & Wilcox

#### 1597. High-Tensile Steel

Bulletin on nickel-copper steel of low-alloy, high-strength type. Youngstown Sheet and Tube

#### 1598. Humidity Recorders

New 6-page bulletin on portable recorders for humidity and temperature. Bristol

#### 1599. Induction Hardening

Bulletin M-1938 on induction hardening machine gives advantages and application of system. Cincinnati Milling Machine

#### 1600. Induction Heating

24-page booklet on low-frequency induction heating used for preheating and normalizing for welding and other industrial applications. Electric Arc, Inc.

#### 1601. Induction Heating

New 36-page bulletin on high-frequency induction heating unit for brazing, hardening, soldering, annealing, melting and bombarding. Lepel

#### 1602. Induction Heating

60-page catalog tells of reduced costs and increased speed of production on hardening, brazing, annealing, forging or melting jobs. Ohio Crankshaft

#### 1603. Induction Heating

12-page bulletin B-6519 on motor generator sets, r.f. generators, work stations, handling equipment. Westinghouse Electric

#### 1604. Industrial Fans

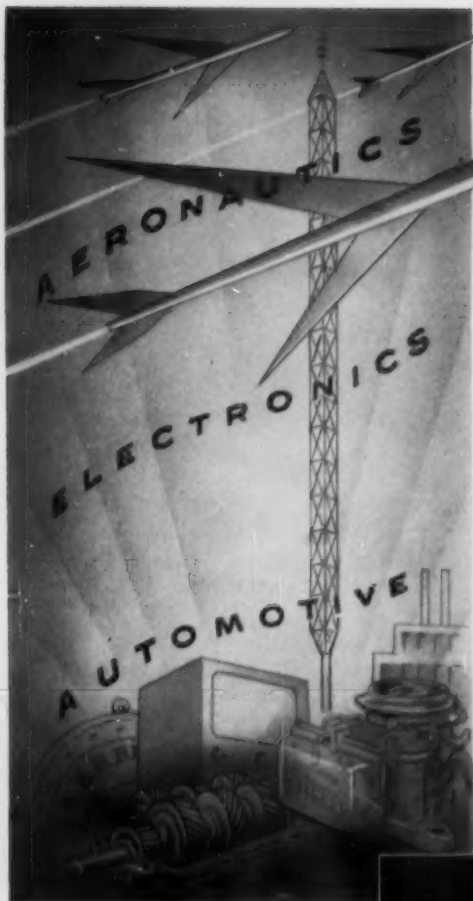
New bulletin C-102 on fans for hot air and gases to 600° F. describes application of forward and backward curving blade fans. Chicago Blower

#### 1605. Inspection

8-page book on cost reduction with magnetic particle inspection. Case studies. Magnafuz

#### 1606. Instruments

New bulletin on manometer-type instruments for pressure, flow and liquid level. Meriam Instrument



# Announcing.. "SUPERCASE"

## OUR NEW PROCESS for NITRIDING STAINLESS STEEL

"SUPERCASE" is especially adaptable for use on parts where an extremely hard, wear resistant surface with maximum corrosion resistance is needed.

"SUPERCASE" has already been successfully proven in use by Electronics, Aircraft, Carburetor, Transmission and Small Parts manufacturers.

"SUPERCASING" is rapidly being adopted by manufacturers in many other fields of industry.

### Advantages of "SUPERCASE" Over Older Nitriding Methods

1. "SUPERCASE" depths are controlled to closer limits. A uniform, extremely hard case, approaching the hardness of a diamond, is obtained by this process with only a light case required. Normal case depth ranges between .0003 to .0007, yet wear tests on "SUPERCASED" gears prove they outlasted, by several times, the life of the unit to be used.
2. "SUPERCASE" may be removed in the event of a change after parts have been finished — the parts re-worked and then re-nitrided.
3. "SUPERCASE" may be done on a selective basis. To machine an area further after nitriding, area can be masked off and will remain soft after processing.
4. "SUPERCASE" can be used on all types of Stainless Steel.

### ADVANTAGES of "SUPERCASE"

#### CLOSER LIMITS

Very Light Case required.

#### REWORKING

Case can be removed, parts reworked and re-nitrided.

#### SELECTIVE BASIS

Small areas may be masked to remain soft after nitriding.

#### VARIETY

"SUPERCASE" may be used on all stainless steels.



Typical "SUPERCASED" Parts



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**1607. Iron Powder**

8-page booklet tells of new type B iron powder. Tables give compressibility, density, green strength and other properties before and after sintering for various mixes. *Scrub Oaks Mine, Alan Wood Steel Co.*

**1608. Leak Detector**

16-page bulletin on leak detector for location and measurement of leaks in evacuated or pressure systems. *Consolidated Vacuum Corp.*

**1609. Lubricant**

8-page folder describes use of molybdenum disulfide lubricant in cold forming, cold heading and other applications. Case histories. *Alpha Corp.*

**1610. Lubricants**

Fifth revision of 4-page booklet on dispersions for industry lists 41 colloidal and semi-colloidal dispersions for the metal working industries. *Acheson Colloids*

**1611. Lubrication**

"Lubrication Newsletter" article on press fitting with molybdenum disulfide lubrication includes plain bearings, ball and roller bearings, gears, sprockets, etc. *Alpha Molykote Corp.*

**1612. Machining Copper**

32-page booklet gives cutting speeds, feeds, rakes, clearances for more than 40 copper alloys. *American Brass*

**1613. Magnesium**

42-page booklet on wrought forms of magnesium. Includes 31 tables. *White Metal Rolling & Stamping*

**1614. Magnesium Extrusions**

36-page bulletin gives values of moment of inertia, section modulus and radius of gyration of bars, tubing, angles, channels, tees, zees and other sections. *Dow Chemical*

**1615. Magnesium-Zirconium**

10-page reprint on an investigation of zirconium chloride, zirconium fluoride, 40% zirconium-magnesium material for making magnesium zirconium alloys. *Titanium Alloy Mfg. Div.*

**1616. Malleable Iron**

12-page Bulletin 5797 on electric-furnace annealing of malleable iron. *General Electric*

**1617. Master Alloys**

Bulletin on custom-made alloys for remelt or reprocessing. *Cannon-Muskegon*

**1618. Melting Aluminum**

Bulletin 310 on furnaces for melting aluminum. *Lindberg Eng'g*

**1619. Melting Furnaces**

28-page catalog on Heroult electric melting furnaces. Types, sizes, capacities, ratings. *American Bridge*

**1620. Metal Identification**

New booklet on Metal Monitor for non-destructive metal identification. *Brush Electronics*

**1621. Microhardness Tester**

Bulletin describes the Kentron microhardness tester. *Torsion Balance Co.*

**1622. Microscopes**

22-page catalog describes microscopes featuring ball bearings and rollers throughout the focusing system and a low-position fine adjustment, providing comfortable operation. *Bausch & Lomb*

**1623. Microscopes**

Catalog on metallograph and several models of microscopes. *United Scientific*

**1624. Moisture Measurement**

12-page bulletin on how to measure water vapor in air and other gases. Gravimetric, dew point and wet and dry

bulb methods, and others. *Pittsburgh Lectrodryer*

**1625. Molybdenum Borides**

Six-page bulletin on applications, chemical, physical and mechanical properties of refractory molybdenum borides. Preparation of compounds. *Climax Molybdenum*

**1626. Molybdenum Carbides**

New 6-page bulletin on applications, physical, chemical and mechanical properties, preparation of molybdenum carbides and nitrides. *Climax Molybdenum*

**1627. Monel**

New booklet on engineering properties of cast Monel. *International Nickel Co.*

**1628. Nitriding**

Data on process for nitriding stainless steel. *Standard Steel Treating*

**1629. Nondestructive Testing**

8-page bulletin on equipment for non-destructive testing of bars, rods, tubing. *Magnetic Analysis*

**1630. Nonferrous Alloys**

Bulletin 154 with chart showing chemical analyses, and properties. Current U.S. Navy, Federal, Military, SAE and ASTM specifications. *Shenango-Penn Mold Co.*

**1631. Nonferrous Wire**

Folder gives wire gage and footage chart and data on beryllium copper, phosphor bronze, nickel, silver, brass and aluminum wire. *Little Falls Alloys*

**1632. Oil Quenching**

8-page brochure tells in detail how carbon steel often can replace alloy steel when additive is used in the quenching oil. *Aldridge Industrial Oils*

**1633. Openhearth**

Brochure on modern openhearth design and construction. *Loftus*

**1634. Optical Instruments**

64-page catalog of optical aids includes some industrial quality control tools—instruments, microscopes, comparators. *Edmund Scientific*

**1635. Ovens**

Bulletin 10-S on cabinet ovens describes those for use with gas, electric and steam heat for temperatures to 600° F. *Young Brothers*

**1636. Ovens**

16-page bulletin No. 53 on various types of core and mold ovens, special ovens and heat treating furnaces. *Carl-Mayer*

**1637. Pickling Baskets**

Data on baskets for degreasing, pickling, anodizing and plating. *Jelliff*

**1638. Pickling Baskets**

12-page bulletin on mechanical picklers, crates, baskets, chain and accessories. *Youngstown Welding & Eng'g*

**1639. Pickling Solutions**

Data on activating compounds (Actane) for removal of films in pickling. Instructions for pickling titanium and aluminum. *Enthone*

**1640. Pipe and Tubing**

68-page book on pipe and tube making, answering many pertinent questions on tube mill operation and production. Engineering data and specifications. *Yoder*

**1641. Plating**

List of chemicals and precious metal catalysts for the preparation of plating baths. *J. Bishop & Co. Platinum Works*

**1642. Plating**

Folder on electroplating with metal fluoroborate solutions—lead, tin, iron, copper, nickel, cadmium and indium. *Baker & Adamson*

**1643. Plating Solutions**

New 4-page bulletin on potassium

cyanide describes its purity, handling, safety and quality control. *Koppers Co.*

**1644. Plating Solutions**

Operating manuals for plating with metal fluoroborate solutions. *Baker & Adamson*. See page 129.

**1645. Potentiometer**

4-page data sheet on potentiometer for instrument checking and temperature measurements. *Leeds & Northrup*

**1646. Potentiometers**

12-page bulletin 270 on several types of potentiometers describes instruments and their uses. Portable models. *Rubicon*

**1647. Precision Casting**

4-page folder on applications of the investment casting process to products in different industries. *Arwood Precision Casting*

**1648. Precision Castings**

New 5-page folder on investment casting. *Engineered Precision Casting*

**1649. Precision Castings**

16-page booklet includes composition and properties of carbon, low alloy, stainless, high temperature and tool steel precision castings. *Crucible Steel*

**1650. Precision Castings**

20-page book on alloys used, specification ranges, advantages and castings made by precision casting. *Haynes Stellite*

**1651. Protective Coatings**

Guide to chemicals and processes for metal protection. *American Chemical Paint*

**1652. Pure Metals**

Data sheets on vacuum melted cobalt, copper, iron and nickel. *Vacuum Metals*

**1653. Pyrometer**

Catalog No. 155 on immersion pyrometer. Leading features, models, specifications. *Pyrometer Instrument Co.*

**1654. Pyrometer Supplies**

56-page bulletin P1238 on thermocouples and pyrometer accessories. Engineering data on selection and installation. *Bristol*

**1655. Quench Agitation**

Information on mixers and agitators, including units applicable to industrial quenching equipment. *Mixing Equipment*

**1656. Quenching**

4-page booklet on continuous automatic quenching tanks. Specifications, construction. *American Gas Furnace*

**1657. Quenching**

24-page booklet on agitation of quenching mediums. Engineering of agitator installations. *U.S. Steel*

**1658. Quenching Oil**

10-page book on new oils for the quenching process gives results on hot wire quench test and in plant operation. *Sinclair Refining Co.*

**1659. Quenching Oils**

8-page booklet on quenching oil gives cooling curves, hardnesses obtained. *Shell Oil Co.*

**1660. Radiant Heat**

Bulletin HD-740R describes and illustrates construction of radiant heat elements and shows how they are installed in furnaces. *Hevi Duty*

**1661. Radiography**

26-page brochure on very high voltage equipment for radiography and how it is used. *High Voltage Engineering*

**1662. Refractories**

24-page booklet on insulating firebrick and cements for use to 3000° F. Shapes, design, suspended arch and wall construction discussed. *Armstrong Cork Co.*

(Continued on page 32-A)

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with stainless

## STAINLESS STEEL VS. OTHER STEELS

Regardless of present conditions it is often difficult to predict future operating requirements. A generous safety factor should be allowed for all possible conditions of corrosion, oxidation, pressures and temperatures. In the range of B&W stainless steels will be found the answers to virtually all of these conditions. It's easy to anticipate substantial

savings in downtime and labor costs in replacing worn-out tubing made from less hardy metals. Be sure with B&W stainless.

Get in touch with Mr. Tubes, your link to B&W, for the story of how you can get more for your money with stainless tubing. *Or write for Bulletin TB 1.*



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**TUBULAR PRODUCTS DIVISION**  
Beaver Falls, Pa. and Milwaukee, Wis.: Seamless Tubing,  
Welded Stainless Steel Tubing  
Alliance, Ohio: Welded Carbon Steel Tubing  
Milwaukee, Wis.: Seamless Welding Fittings

TA-5035(P)

(Continued from page 31)

### 1663. Refractories

12-page brochure on products for casting special refractory shapes and for gunning and troweling applications, for services to 3000° F. *Johns-Manville*

### 1664. Refractories

24-page booklet on how refractory grain is produced. Chemical and physical characteristics, sizes, applications. *Norton*

### 1665. Refractory Cement

Bulletin discusses refractories and heat-resistant concrete. *Lumnite Div.*

### 1666. Resistance Welding

24-page catalog on equipment for resistance welding includes reference tables and property and application charts. *Ampco*

### 1667. Rhodium Plating

Data on properties, thicknesses required, costs, operation, applications. *Technic*

### 1668. Rhodium Plating

Revised booklet with data on rhodium plating and different applications. *Baker & Co.*

### 1669. Rust Preventives

12-page bulletin on water-soluble rust preventive. *Production Specialties*

### 1670. Salt Bath Furnaces

Data on salt bath furnaces for batch and conveyorized work. *Upton*

### 1671. Salt Baths

32-page bulletin on salts for tempering, annealing, neutral hardening, martempering and carburizing. Heat treating data. *E. F. Houghton*

### 1672. Sand Blasting

New 4-page bulletin 1256 on sand blasting machines for cleaning, deburring, surface preparation. *Leiman Bros.*

### 1673. Saws

Catalog C-53 describes 35 models of metal-cutting saws. *Armstrong-Blum*

### 1674. Selective Strippers

Bulletin on materials for selective stripping of one metal from another—electroplated metals, solder or brazing excess. *Enthone*

### 1675. Shell Molding

8-page booklet on silicones for the shell molding process describes three different products. *Silicones Div., Union Carbide and Carbon Corp.*

### 1676. Shell Molding

Bulletin on shell-molded castings serv-

ice lists ferrous and nonferrous alloys handled and typical parts produced. *Crobbalt*

### 1677. Shotblasting

16-page "Primer on the Use of Shot and Grit". Problems of blast cleaning operations. *Hickman, Williams*

### 1678. Sintered Carbides

24-page booklet on the characteristics of the various grades, for research and design engineers. *Kennametal*

### 1679. Soldering Fluxes

Discussion in "Federated Metals Digest", Vol. 3, No. 1, of various types and their advantages. *Federated Metals*

### 1680. Spectroanalysis

New catalog on Varisource excitation unit. Information on the circuit parameters. *Jarrell-Ash*

### 1681. Spectrograph

24-page booklet on Echelle spectrographs. Advantages. Type of work produced. *Bausch & Lomb*

### 1682. Stainless Castings

8-page bulletin gives recommendation charts for type of stainless to use in various corrosive solutions, under various conditions. *Waukesha Foundry*

### 1683. Stainless Shapes

Folder on hot rolled stainless steel shapes and their advantages. *Disston*

### 1684. Stainless Steel

Booklet on 430 stainless. Properties, fabrication. *Sharon Steel*

### 1685. Stainless Steel

32-page book on corrosion resistance of stainless steels. 18 tables on tests in acid, neutral and alkaline solutions. *International Nickel*

### 1686. Stainless Steel

12-page booklet on new AM 350 chromium-nickel-molybdenum stainless steel which is hardenable by subzero cooling or double aging. *Allegheny Ludlum*

### 1687. Stainless Steel

Data card 178 on stress-rupture properties of chromium-nickel stainless steel weld deposits. *Babcock & Wilcox Co.*

### 1688. Stainless Steel

20-page catalog on corrosion resistance, applications and working characteristics of 20% chromium-29% nickel stainless steels, with and without columbium. *Carpenter Steel*

### 1689. Stainless Steels

20-page book on uses of stainless steels. *Electro Metallurgical*

### 1690. Stainless Strip

32-page brochure on 20 types of stainless strip steel. Recommended applications, chemical, physical and mechanical properties, corrosion resistance. *Superior Steel Corp.*

### 1691. Stainless Tubing

New 12-page brochure on stainless steel heat exchanger and condenser tubes. Process, manufacture, chemical composition and analysis. *Republic Steel*

### 1692. Stainless Wire

New 32-page aid to selection of proper stainless steel wire for particular application discusses austenitic, ferritic and martensitic grades. *Crucible Steel*

### 1693. Steel

256-page handbook lists sizes, weights, lengths, steels available, shapes. Data on mechanical properties, standard steel compositions, hardness numbers conversions. *Ryerson*

### 1694. Steel 52100

New stock list on 52100 tubing, bars and ring forgings. *Peterson Steels*

### 1695. Steel Tubing

48-page Handbook F-3 on fabricating and forging steel tubing. Bending, shaping, cutting and joining operations described. *Ohio Seamless Tube*

### 1696. Steelmaking

8-page "Carbon and Graphite News" tells how quality steels are produced in electric furnaces at Timken Roller Bearing Co. *National Carbon*

### 1697. Sub-Zero Equipment

12-page catalog of chilling machines and temperature testing units. *Cincinnati Sub-Zero Products*

### 1698. Sulphur Determination

New bulletin on high frequency combustion unit for determination of sulphur. *Lindberg Engineering*

### 1699. Swaging

Catalog on swaging machine. *Fenn Mfg.*

### 1700. Temperature Control

4-page data sheet on electro-pneumatic controllers. Specifications, standard ranges, equipment for complete control system. *Leeds & Northrup*

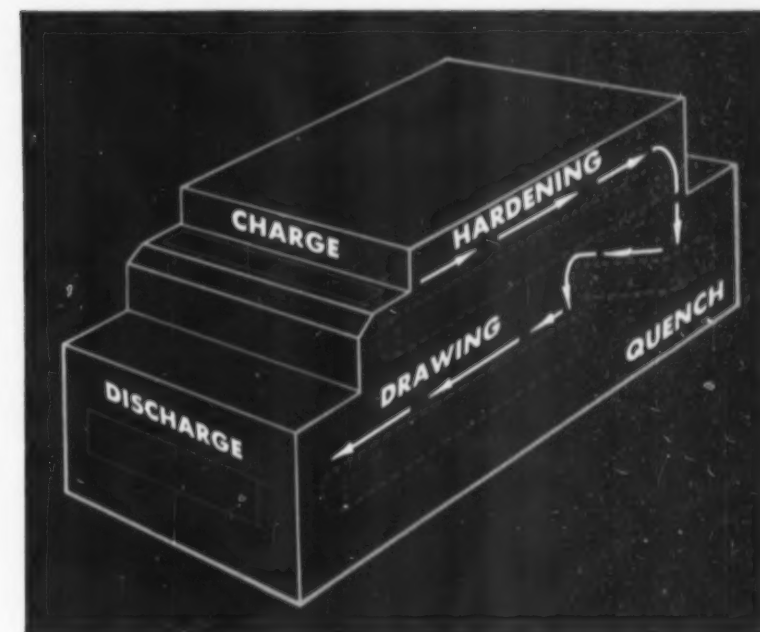
### 1701. Temperature Conversion

16-page temperature conversion booklet and electromotive force of thermocouple alloys in absolute millivolts. *Wheelco*

### 1702. Temperature Measuring

New 24-page catalog of heat radiation

BLAZING THE HEAT TREAT TRAIL WITH HOLCROFT



## LET'S TALK ABOUT DOUBLE DECK FURNACES

Ever try to fit two entirely different furnaces into floor space where only one will go? It can be done. All you do is stack one on top of the other!

Holcroft did it first a good many years ago. The furnace illustrated—by no means the first of its type—was built for a Detroit automobile plant back in 1932.

Three thousand pounds of connecting rods and spindles each hour were treated—moving first through a hardening furnace on the upper deck and then down a chute into a quench tank. Work was elevated by means of a reverse conveyor from the tank and loaded onto the return conveyor belt of the lower furnace for drawing and discharge.

Furnaces like these can be fully automated, or have manual transfers. They can be designed to heat treat a specific part, or to be used for general production.

This is the kind of heat treat background and creative engineering that is available to you when you come to Holcroft. It's a good idea to do it—today!

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Industrial Instruments • Automatic Controls • Air Distribution Products  
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Products • Metal Cutting Tools • Machine Tools • Textile Machinery

detectors for continuous temperature measurement to 5000° F. Leeds & Northrup

#### 1703. Tempering

Bulletin 1E-11 on tempering and other applications in liquid baths. Kemp

#### 1704. Test Bars

New 18-page bulletin No. 168 on design of test bar patterns, production of test bars, testing procedures. Federated Metals Div., American Smelting and Refining

#### 1705. Test Specimens

Data on machine for cutting test specimens to ASTM specifications. Sieburg Industries

#### 1706. Tester

Bulletin 164 on Dyhedron, dynamic diamond tester for hardness and lubricity of materials. Taber Instrument

#### 1707. Testers

Data on portable spot tester for qualitative analysis. Spot-Testers, Inc.

#### 1708. Testing Machines

8-page folder on Amaler machines for tests in tension, compression, torsion, shear, fatigue, bending and ductility. Bulletins on wear testing, and testing of miniature samples. Buehler

#### 1709. Testing Machines

8-page guide to Riehle testing machines and instruments. Riehle

#### 1710. Testing Machines

Universal testing machines and equipment are diagrammed, described and illustrated in 20-page Bulletin 43. Tinius Olsen

#### 1711. Thermocouple Alloys

20-page booklet on chromel-alumel alloys gives sizes, temperature-millivolt equivalents, standards, applications. Hoskins Mfg.

#### 1712. Thermocouple Tubes

New 4-page bulletin on standard thermocouple protecting tubes and wells. Claud S. Gordon

#### 1713. Thermocouples

8-page bulletin 22 on industrial thermocouples for all pyrometers. Thermo Electric

#### 1714. Thermocouples

32-page file book on pyrometer accessories. Selection of thermocouple and protective tube. West Instrument Corp.

#### 1715. Thermostats

New bulletin describes styles available, operating principles, performance data, ratings, dimensions. Stevens Mfg. Co.

#### 1716. Titanium Alloy

Data on ternary alloy with 3% aluminum and 5% chromium gives physical properties, forging temperatures, high temperature characteristics. Mallory-Sharon Titanium

#### 1717. Titanium Tubing

Bulletin No. 42 on small tubing of titanium; processing, fabrication, characteristics. Superior Tube

#### 1718. Tool Steel

Folder on high carbon, high-vanadium tungsten-base high speed steel. Latrobe

#### 1719. Tool Steel

44-page stock list is indexed and includes sizes, weights and analyses. Decimal conversion and hardness conversion tables. Uddeholm

#### 1720. Tool Steel Guide

New 70-page brochure includes information on 50 types of tool steels and cold finishing products. Vanadium-Alloys

#### 1721. Tool Steels

32-page catalog of all Carmet grades and blanks, tools, die sections. Special preforming to order. Allegheny Ludlum

#### 1722. Tube Welding

Bulletin on high-frequency tube welding equipment. Applications, materials which may be welded by this process. New Rochelle Tool

#### 1723. Ultrasonic Cleaning

Folder on Sonogen ultrasonic generator for metal cleaning. Branson

#### 1724. Ultrasonic Testing

Data folder describes instruments using ultrasonics for various tests—immersion, "B" scan and flaw recorder. Curtiss-Wright

#### 1725. Ultrasonics

Bulletin GEA-6239 on ultrasonic power generators for industrial cleaning equipment. General Electric

#### 1726. Ultrasonics

New bulletin MW-103 on use of ultrasonics in degreasing, electroplating, drilling, and grinding operations. Acoustica Associates

#### 1727. Vacuum Metallizing

8-page catalog 551 on production and

experimental-type metallizing units. High Vacuum Equipment Corp.

#### 1728. Vacuum Metallurgy

Articles on commercial vacuum furnaces for metals and alloys and some aspects of vacuum melted metals. National Research

#### 1729. Vacuum Pump

New 8-page booklet 756 on diffusion and booster pumps for high vacuum processing. F. J. Stokes Machine

#### 1730. Vanadium

"Vancoram Review", Spring 1956, tells story of discovery of vanadium ore in Peru. Vanadium Corp.

#### 1731. Welding

Data on welding positioners from 500 to 100,000 lb. capacity. Harnischfeger

#### 1732. Welding Alloy Steel

44-page Data Book 4D covers all types of welding of nickel alloy steels. International Nickel

#### 1733. Welding Copper

24-page booklet on oxyacetylene, carbon-arc and metal-arc welding techniques for copper and copper alloys. Revere

#### 1734. Welding Equipment

Catalog on Cadweld process and arc-welding accessories. Erico Products

#### 1735. Welding Magnesium

Various welding processes for magnesium, stress relief and recommended procedures. Brooks & Perkins

#### 1736. Welding Rods

New bulletin on processing of welding rod materials, master alloys and other specialized products. Shieldalloy

#### 1737. Wire Cloth

Bulletin 113 on wire cloth in various alloys, in bulk or specially fabricated parts. Cambridge Wire Cloth

#### 1738. X-Ray

12-page bulletin on gamma radiography tells how to select the source, equipment, techniques and fundamentals of gamma radiation. Picker X-Ray

#### 1739. X-Ray Equipment

Bulletins on No. 2 SPG X-ray detector describe specifications and advantages. X-Ray Dept., General Electric

#### 1740. X-Ray Supplies

Bulletin on liquid X-ray developer, replenisher and fixer. Philip A. Hunt Co.

JUNE, 1956

1433	1460	1487	1514	1541	1568	1595	1622	1649	1676	1703	1730
1434	1461	1488	1515	1542	1569	1596	1623	1650	1677	1704	1731
1435	1462	1489	1516	1543	1570	1597	1624	1651	1678	1705	1732
1436	1463	1490	1517	1544	1571	1598	1625	1652	1679	1706	1733
1437	1464	1491	1518	1545	1572	1599	1626	1653	1680	1707	1734
1438	1465	1492	1519	1546	1573	1600	1627	1654	1681	1708	1735
1439	1466	1493	1520	1547	1574	1601	1628	1655	1682	1709	1736
1440	1467	1494	1521	1548	1575	1602	1629	1656	1683	1710	1737
1441	1468	1495	1522	1549	1576	1603	1630	1657	1684	1711	1738
1442	1469	1496	1523	1550	1577	1604	1631	1658	1685	1712	1739
1443	1470	1497	1524	1551	1578	1605	1632	1659	1686	1713	1740
1444	1471	1498	1525	1552	1579	1606	1633	1660	1687	1714	1741
1445	1472	1499	1526	1553	1580	1607	1634	1661	1688	1715	1742
1446	1473	1500	1527	1554	1581	1608	1635	1662	1689	1716	1743
1447	1474	1501	1528	1555	1582	1609	1636	1663	1690	1717	1744
1448	1475	1502	1529	1556	1583	1610	1637	1664	1691	1718	1745
1449	1476	1503	1530	1557	1584	1611	1638	1665	1692	1719	1746
1450	1477	1504	1531	1558	1585	1612	1639	1666	1693	1720	1747
1451	1478	1505	1532	1559	1586	1613	1640	1667	1694	1721	
1452	1479	1506	1533	1560	1587	1614	1641	1668	1695	1722	
1453	1480	1507	1534	1561	1588	1615	1642	1669	1696	1723	
1454	1481	1508	1535	1562	1589	1616	1643	1670	1697	1724	
1455	1482	1509	1536	1563	1590	1617	1644	1671	1698	1725	
1456	1483	1510	1537	1564	1591	1618	1645	1672	1699	1726	
1457	1484	1511	1538	1565	1592	1619	1646	1673	1700	1727	
1458	1485	1512	1539	1566	1593	1620	1647	1674	1701	1728	
1459	1486	1513	1540	1567	1594	1621	1648	1675	1702	1729	

#### METAL PROGRESS,

7301 Euclid Avenue, Cleveland 3, Ohio

Please have literature circled at the left sent to me.

Name

Title

Company

Address

City and State

Postcards must be mailed prior to Aug. 1, 1956.  
Students should write direct to manufacturers.

**NOW...  
ACTIVELY ENTERING  
THE STAINLESS STEEL  
FAMILY**



# **AL CHROMIUM-MANGANESE LOW-NICKEL STAINLESS GRADES**

## **WRITE FOR THE ASSISTANCE YOU NEED**

### **1. "TECHNICAL STUDIES #3"**

... essential information on the composition, properties, fabricating methods and applications of AL chromium-manganese, low-nickel stainless steels. *Write for your copy.*

### **2. TEST SAMPLES**

... We'll be glad to supply engineering assistance, and actual samples of these 200-Series steels for testing under your processes and conditions.

**ADDRESS DEPT. MP-78**

*Here is a direct answer to the recurring problem of nickel shortage.* For many users of chromium-nickel austenitic stainless steels, the new AISI 200-series of chromium-manganese low-nickel austenitic grades can be a source of immediate relief—and an avenue to the reduction and possible avoidance of nickel shortage problems in the future.

In many cases, you can switch directly from the older Type 301 and 302 grades to the new AL Stainless Type 201 and 202 steels, using the same fabricating processes and securing about the same results. There's nothing new to learn, and no loss in performance in practically all applications. In

certain respects, these steels have better properties than the older materials and may be used to actual advantage in some cases.

We also produce low carbon grades of these chrome-manganese steels, arbitrarily designated Types 204 and 204L (similar to the older grades 304 and 304L) ... as well as a lower-chromium, higher-manganese grade designated Type CM, which contains only 1% nickel. Allegheny Ludlum has pioneered in the development and application of these low-nickel stainless steels. We know what the new grades will do ... let us help you put them to use. *Allegheny Ludlum Steel Corporation, Oliver Bldg., Pittsburgh 22, Pa.*

**For Stainless Steel in ALL Forms—call**

# **Allegheny Ludlum**



WOW 5750

**Warehouse stocks carried by all Ryerson Steel plants**

**WHEN IT'S MOVING...MAKE IT TUBING**

# Pound for Pound, Tubular



Wheeled chairs get stiff workouts in fast-moving paraplegic basketball. Tubular construction keeps them strong, safe, maneuverable. When it's moving, make it steel tubing.

## REPUBLIC



*World's Widest Range of Standard Steels*

# Construction is STRONGEST!

At any given weight, tubing is strongest of all mechanical shapes . . . stronger under compressive load . . . stronger as a beam . . . stronger in torsion.

And, dollar for dollar Republic ELECTRUNITE Steel Mechanical Tubing is your best buy. ELECTRUNITE is the original electric resistance welded tube. It's the quality tube of industry, available in a wide variety of forms, sizes and gages . . . in both carbon and stainless steel.

For volume production, ELECTRUNITE tubing is consistently uniform, foot to

foot, shipment to shipment. It offers uniform wall thickness and concentricity. Surfaces are free from scratches and pit marks. It offers uniform response to heat treatment. It is easy to fabricate . . . often eliminates some costly fabricating or machining operations.

When your product must be strong, safe, lightweight, investigate Republic ELECTRUNITE Steel Tubing. Republic engineers can help you design it into your products and processes, economically and profitably. Send coupon for facts.

## MORE REPUBLIC PRODUCTS MADE FOR MOVEMENT:



"I PUT REPUBLIC NYLOK NUTS TO THE TEST every time I ride my Taylor Tot," reports this young test driver. In spite of all the bumps, bounces and jolts, Nylok Nuts always hold tight. The reason: a special Nylon plug that assures positive locking in any position wherever you stop wrenching. Send coupon for details.



THESE REET DIGGER TEETH ARE 34% STRONGER since John Deere switched to alloy steel. Originally fabricated from carbon steel, they would sometimes break under stress. By taking advantage of alloy's hardenability—plus superior strength—bending and abrasion problems have been eliminated. Send coupon for complete data on Republic Alloy Steels.



DOUGLAS AIRCRAFT ADDED A PASSENGER—AT NO INCREASE IN WEIGHT on their new DC-7 superliner. How? By substituting Titanium for other metals normally used in nacelle construction. Republic is an old hand at this high strength-to-weight business. Send coupon for information on how Republic Titanium and Titanium Alloys may help your product.

# STEEL

*and Steel Products*

### REPUBLIC STEEL CORPORATION

Dept. C-1249  
3188 East 45th Street  
Cleveland 27, Ohio

Please send me more information on:

☐ ELECTRUNITE® Mechanical Tubing ☐ Alloy Steels  
☐ NYLOK® Nuts ☐ Titanium

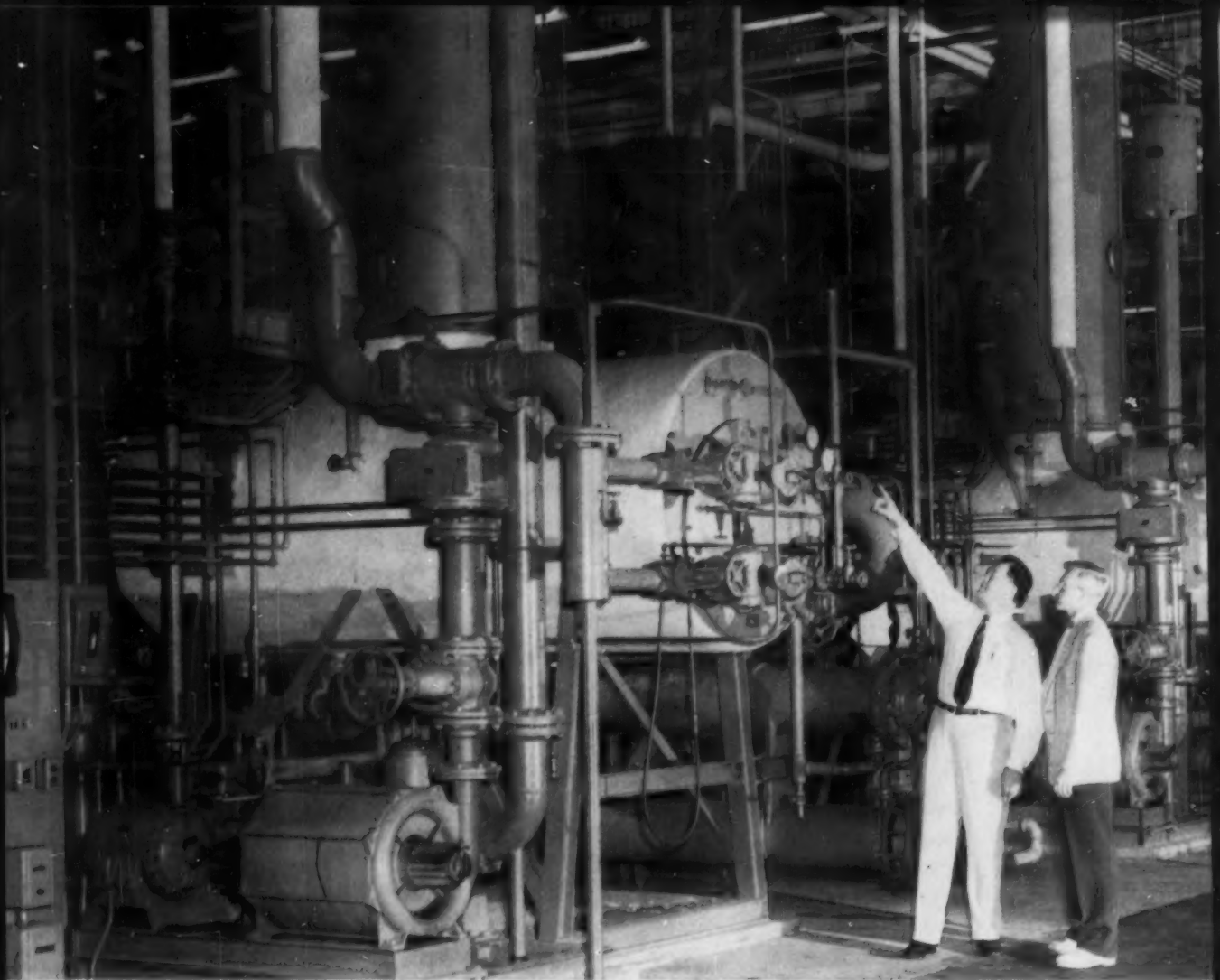
\*U.S. Pat. No. 2,450,694 and pending applications.

Name \_\_\_\_\_ Title \_\_\_\_\_

Company \_\_\_\_\_

Address \_\_\_\_\_

City \_\_\_\_\_ Zone \_\_\_\_\_ State \_\_\_\_\_



**DIFFERENT COMPOSITIONS** of G-E Neutralene gas are possible to fit various applications—annealing, hardening, brazing, sintering, and carburizing. G-E gas producers shown are rated at 15,000 CFH; complete line includes ratings from 200 CFH.

## CAPSULE CASE HISTORIES SHOW BENEFITS OF USING PROTECTIVE ATMOSPHERES



**OXIDES REDUCED** when parts are bright annealed in Exalene gas. Pan on left is shown before cleaning; center pan, after pickling only; pan on right, after bright annealing only. Exalene gas is used also in normalizing, hardening, brazing, and sintering.



**SCALE-FREE UNPITTED** drill chuck on right was hardened in Thermalene atmosphere, does not need subsequent cleaning; chuck on left was hardened in air. Thermalene gas is used also in bright annealing, normalizing, hardening, brazing, sintering, and carburizing.

**GENERAL ELECTRIC SELLS  
A COMPLETE LINE OF  
HEAT PROCESSING EQUIPMENT**  
**FURNACES • METAL-SHEATH • INDUCTION**



Box



Cylindrical Pit



Roller Hearth



Elevator

# Eliminate Expensive After-work— Produce Clean Heat-treated Parts with G-E Protective Atmospheres

Protective atmospheres help you turn out heat-treated parts that are free from scale or oxides. They enable you to turn out a more salable product . . . at lower cost. This is true because pickling, grinding, machining, sandblasting, and similar operations are often made unnecessary.

General Electric offers various types and sizes of gas producers that let you manufacture atmospheres inexpensively—right in your own plant. You can prepare these atmospheres to provide exactly the right quality protection for your particular process. G-E protective atmospheres include: Exalene, an exothermic gas; Neutralene\*, a CO<sub>2</sub>-free, dry, exothermic gas; Thermalene\*, an endothermic gas; Ammalene, dissociated ammonia.

Check these benefits of using protective atmospheres:

**PREVENTING OXIDATION** of metal surfaces during furnace heating is a primary advantage of protective atmospheres. Parts are produced at less cost and in a shorter total time cycle when scale formation is eliminated.

**REDUCING OXIDES** which have already formed is easily done by heating in a furnace supplied with the proper protec-

tive atmosphere. This reducing, or cleaning, is often used to prepare steel for porcelain enameling, galvanizing, or for furnace brazing.

**CONTROLLING SURFACE COMPOSITION** of metals in such operations as carburizing, nitriding, and prevention of decarburizing requires closely controlled furnace atmospheres.

**ACCESSORY EQUIPMENT** to meet specific needs is available:

Sulfur Removers take out sulfur dioxide and hydrogen sulfide where sulfur might harm the work or the furnace.

Regenerative-type Dryers remove moisture from gases. Can be had with closed-system reactivation for high-purity uses.

Refrigerated Gas Coolers remove some of the moisture from gases. These coolers may be used with regenerative-type dryers to reduce costs of preparing gases with low dew points.

**COMPLETE SERVICES** of your local G-E Apparatus Sales Representative include helping you to choose the most effective furnace atmosphere for your particular application . . . and to do it at lowest cost. Call him or send in coupon below for free descriptive bulletin.

\*Reg. Trade-mark of General Electric Co.

## GENERAL ELECTRIC

### FREE BULLETIN

Section D721-7  
General Electric Company  
Schenectady 5, N. Y.

Please send me a copy of your bulletin, Protective Atmospheres, GEA-5907.

NAME

COMPANY

ADDRESS

CITY

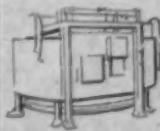
STATE



**CLEANING ELIMINATED** when stainless steel parts are brazed in Ammalene gas. Right-hand part is shown as it came from the brazing furnace—bright and clean.



Mesh Bell



Rotary Hearth



Tower



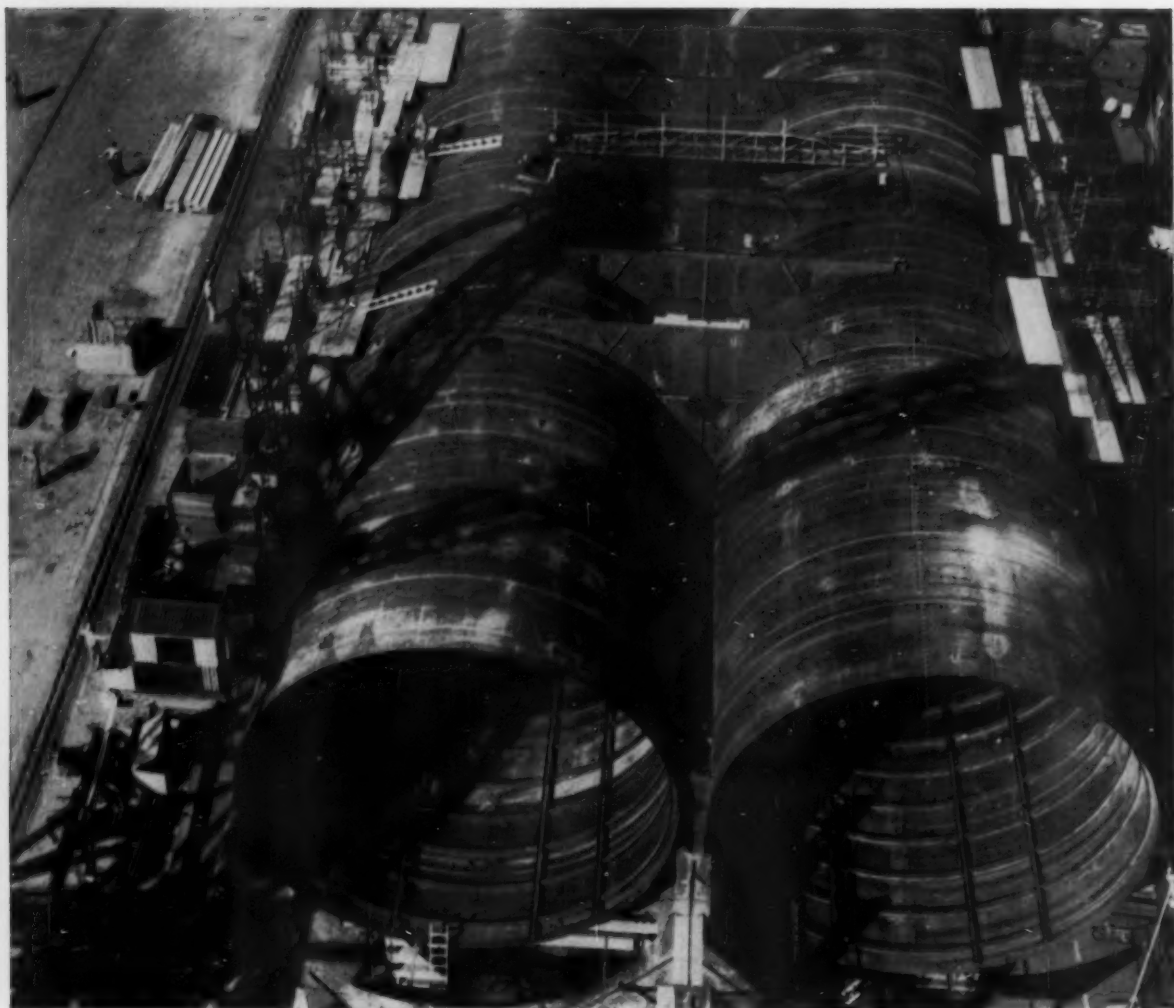
Cylindrical Bell



Metal-sheath



Electronic Induction



## ***GAS* HELPS MARYLAND SHIPBUILDING SHAPE FRAMES FOR NEW HARBOR TUNNEL**



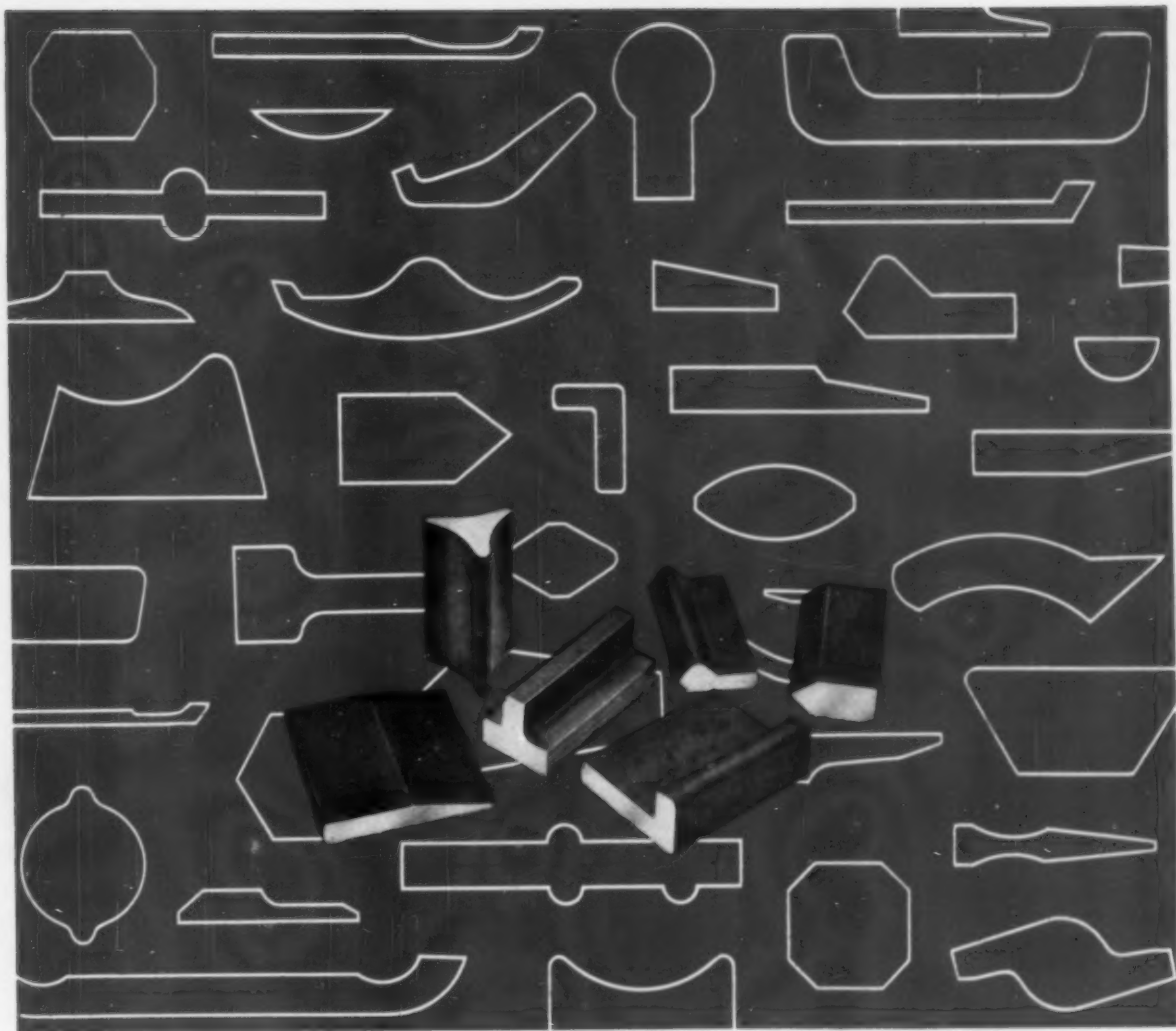
A huge Gas-fired furnace at Maryland Shipbuilding and Drydock Company, Baltimore, Maryland proved its advantages when that company was awarded a construction contract for part of Baltimore's vast new \$140,000,000 Harbor tunnel project.

When Maryland Shipbuilding and Drydock Company installed their two new furnaces—for heating plates and angles—it was decided to use Gas, based on its superior temperature control, lower maintenance, and higher output due to faster heating-up

and less loss of time in changing operating temperatures.

The Gas-fired furnace is now heating 26'6" long T-bars that are shaped and welded, in sets of four, to form 35' circular frames used in the tubular sections of the Harbor tunnel.

For information on how Gas can help you in your production operations, call your Gas Company industrial specialist. He'll be glad to discuss with you the economies and outstanding results you get with Gas and modern Gas-fired industrial equipment. *American Gas Association.*



## Crucible special shapes

*for better alloy steel parts at lower cost . . .*

If you're machining intricate sections from solid bars—or using expensive forgings—stop! Choose instead, a *Crucible special shape* that approximates the finished part. *Crucible special shapes* eliminate rough-machining operations . . . reduce scrap losses.

There's practically no limit to the *special shapes* available at Crucible, in a wide variety of

alloy steels. Rolls for over 400 special shapes are available—other shapes can be rolled to your specifications. Your local Crucible representative can give you the whole story of how *special shapes* can cut costs—save time. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

**CRUCIBLE**

first name in special purpose steels

**Crucible Steel Company of America**

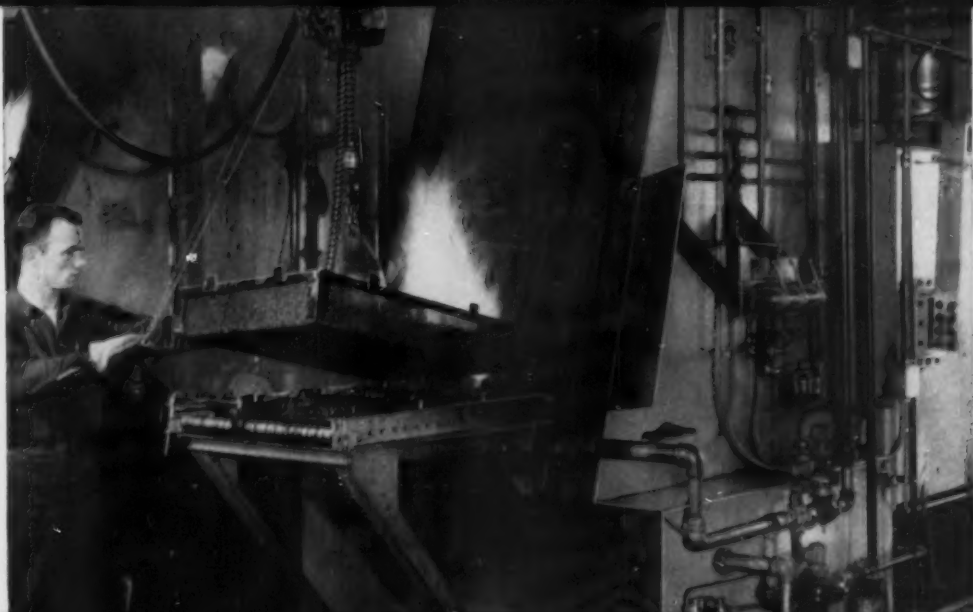
## ALLIED

New Lindberg electric furnace with CORRATHERM element at Allied Metal Treating Corporation, Kenosha, Wisconsin. This furnace is used 24 hours a day, 6 days a week, for carbonitriding, clean hardening pinion gears, hardening crank shafts after carburizing and carburizing small gears and shafts.



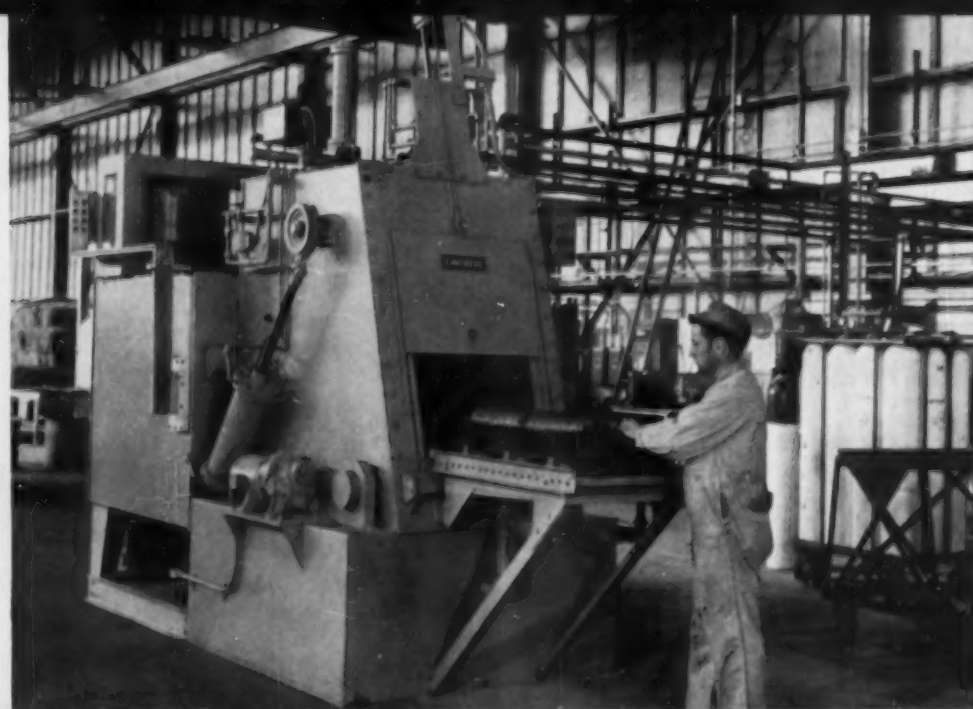
## EKLUND

Installation of new Lindberg furnace with CORRATHERM electric element at Eklund Metal Treating, Inc., Rockford, Illinois. Furnace used 24 hours a day, 7 days a week, for carburizing gears and machine tool parts, carbonitriding sheet metal screws and automotive parts, and hardening and tempering bolts.



## PERFECTION

Lindberg electric furnace with CORRATHERM element just installed at Perfection Tool & Metal Heat Treating Company's Lombard, Illinois plant. This furnace is being used 24 hours a day, 6 days a week, for carbonitriding and carburizing parts for automotive and farm implement industries.



# COMMERCIAL HEAT-TREATERS QUICK TO ADOPT LINDBERG ELECTRIC CARBONITRIDING FURNACES WITH NEW CORRATHERM HEATING ELEMENT

It is significant that commercial heat-treaters, always in the lead in the acceptance and development of better heat-treating methods, have been among the first to appreciate the revolutionary advantages of Lindberg's newly announced CORRATHERM electric heating element.

Recent Lindberg CORRATHERM-equipped furnace installations in plants of three leading midwestern commercial heat-treaters are shown on the opposite page.

Where electricity is the preferred source of heat Lindberg furnaces with CORRATHERM provide to the fullest degree the versatility and dependability required in efficient commercial heat-treating. Ideal for carbonitriding, they are readily applicable to other processes—carburizing, carbon restoration, bright hardening or annealing, and normalizing.

Whether your heat-treating operations are commercial or captive, large or small, the CORRATHERM element in Lindberg electric furnaces offers you these exclusive advantages:

**Low voltage**—operates at extremely low voltage. No leakage through carbon saturation.

**Atmosphere Circulation**—elements act as baffle to direct circulation of convection streams.

**Safety**—extremely low voltage eliminates shock or short hazards.

**Durability**—watts density at all time low. Element practically indestructible.



This shows how the new Lindberg CORRATHERM electric heating element fills the furnace with walls of glowing heat. Note also that CORRATHERM is conveniently hung from simple brackets requiring no complicated connections or construction.

*CORRATHERM is an exclusive Lindberg development created in Lindberg laboratories by Lindberg metallurgists and engineers. To find out how its advantages can be applied to your heat-treating processes consult your nearest Lindberg Field Representative. (Look in classified phone book.)*

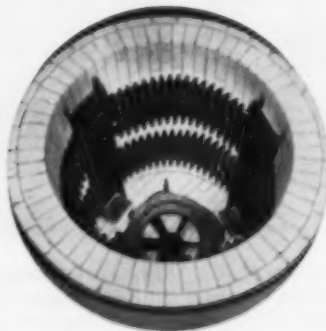
## LINDBERG ENGINEERING COMPANY

2448 West Hubbard Street, Chicago 12, Illinois

Los Angeles Plant: 11937 Regentview Ave., at Downey, California



Installation of CORRATHERM elements in one of two large rotary furnaces just erected in the field by Lindberg's associate company, Lindberg Industrial Corporation.



Installation of Lindberg CORRATHERM-equipped carburizing pit-type furnace in plant of Lindberg Steel Treating Co., Melrose Park, Ill.



Safety! Extremely low voltage makes CORRATHERM elements completely safe. Let operator or work load bang it if they will. Neither element nor operator will be hurt.



**Research** in titanium reduction and annealing by Dr. E. W. Johnson, Advisory Metallurgist, developed this vacuum arc furnace for commercial use. The consumable sponge titanium electrode, shown, is reduced to a highly pure titanium ingot.



**Expanded design engineering** is supervised by R. W. Brown, Engineering Manager, for Westinghouse gas and electric furnaces and atmosphere generators. Additional engineering facilities handle induction heating equipment.

# Launching a new Industrial Heating Division

## L. R. HAGUE OF WESTINGHOUSE CARRIES NEW PROFIT OPPORTUNITIES TO CUSTOMERS

Big and growing opportunities in metal treating are creating a need for broader equipment know-how and service. The answer to these needs is being put before customers by L. R. Hague, Division Manager, in over 10,000 miles of introducing Westinghouse major new Industrial Heating Division.

### Cadre of key men

"Westinghouse new organization grows around key men with careers in metallurgical processing," reports Hague. "Their experience expedites problem solving on all types of equipment... gas and electric furnaces, atmosphere generators and induction heating equipment applications. Some of these involve

more than one type of heat-treating and many installations incorporate work-handling advantages for in-line production."

### Turn-key contracts

Manufacturing and field service organizations have expanded, too. They integrate their planning with customer timetables for equipment installation. Full erection and supervision of start-ups are provided in what Westinghouse calls *turn-key* contracts.

### Research rapid

Hague points, in addition, to Westinghouse pioneering in new fields of metallurgy. "Developments in vacuum metallurgy, induction heating and other techniques are progressing rapidly," he said. "Equipment development is a part of Westinghouse large metallurgical research program."

### On-the-spot planning

This year many plants plan heat-treating expansion. Many more will check heat-treating obsolescence—looking for troublemakers that cause extra handling, distortion, decarburization or scaling. "Call your local Westinghouse industrial heating sales engineer for counsel on these problems," Hague recommends. "He will bring broad equipment knowledge and service facilities for new profit opportunities." J-10449

YOU CAN BE SURE...IF IT'S

# Westinghouse



**Project engineers**, C. E. Peck and E. J. Seabold, work with Westinghouse customers in engineering, manufacture and installation of units such as this continuous annealing furnace, to be tested and ready to go in the customer's plant.

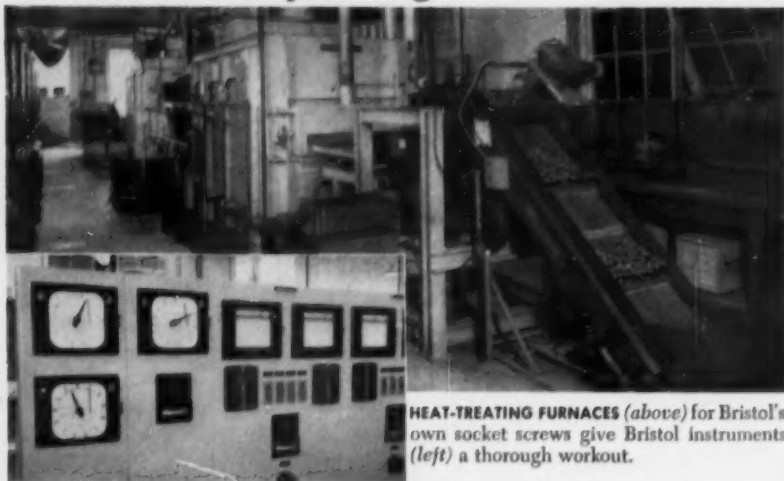


**Industrial heating sales engineers** are kept abreast of new developments and techniques in regular reviews with L. H. Gillette, Marketing Manager, and R. R. La Pelle, Furnace and Atmosphere Generator Application Manager.

# BRISTOL'S Instrumentation News

• News of instrumentation and automatic control in industrial heating and metallurgy •

## New instruments pass tough "field" tests at home



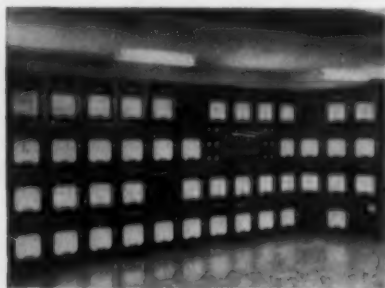
HEAT-TREATING FURNACES (above) for Bristol's own socket screws give Bristol instruments (left) a thorough workout.

New Bristol instruments for metal-treating operations have a ready-made proving ground in Bristol's own socket screw manufacturing division.

Bristol instruments monitor and automatically control every phase of the Socket Screw Division's metal treatment—including a variety of continuous and batch-type furnaces, salt-baths, and tinning and degreasing operations for specialty products.

Completely automatic control assures highest quality and uniformity for Bristol socket screw products. New instruments get grueling "field" tests before they're released for general distribution. And, last but not least, visitors to the Waterbury plant can see Bristol instruments under actual load conditions.

Drop in, when you're in the New England area, and watch these precision instruments at work!



## Telemetering helps control steel plant fuel

This Bristol telemetering installation helps U. S. Steel, Gary, Indiana, get the highest steel production with the lowest possible fuel cost.

The panel shows the amount of coke-oven and blast-furnace gas used throughout the plant as well as gas pressures at critical locations. With this complete supply and demand information at their fingertips, fuel dispatchers can control distribution for maximum efficiency and economy.

## Precision rolling mill produces steel tapes 0.000125" thick

This precision cold-strip mill at The Arnold Engineering Company, Marengo, Illinois, rolls ultra-thin high-permeability strips for magnetic cores. The core strips may be as thin as 0.000125" and must be held to extremely close tolerances. To achieve the necessary precision, AccuRay gauges—employing Bristol Dynamaster recorders—measure thickness of material on both sides of the rolling mill. The AccuRay equipment is built by Industrial Nucleonics, Columbus, Ohio.



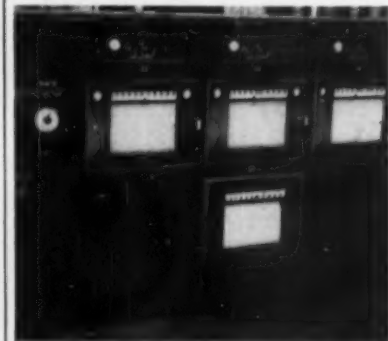
## New control techniques cut fuel bills for metals

In 20 years, fuel required for ingot heating has dropped 50 to 60%.

A big share of the credit for this fuel economy goes to automatic control and instrumentation techniques developed recently. These new techniques, with better, faster, more accurate sensing and response, have chalked up significant savings, not only in fuel, but also in fixed charges, rolling time, and maintenance costs.

Probably most important for big savings is control of furnace temperature and atmosphere. Furnace pressure may be regulated by positioning the stack damper. Fuel-air ratio can be controlled by a valve in the air line. Air requirements for combined fuels may be totaled for better distribution of fuel throughout the plant.

Proper temperature-time sequences or "time cycles" also rack up big savings. Step heating sequences, differing for various metal ingots, no longer need be programmed by rule of thumb. Instead, any predetermined sequence of temperatures can be maintained automatically and easily changed to suit particular batches.



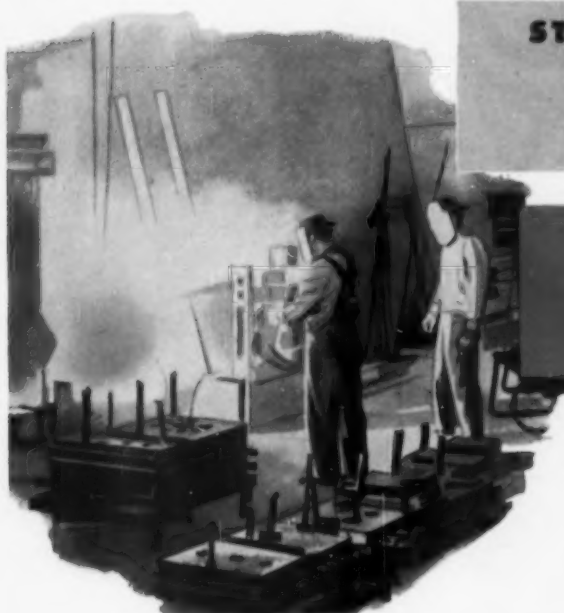
THESE BRISTOL ELECTRONIC AND AIR-OPERATED pyrometers automatically control regenerative soaking pits. Platinum, platinum-rhodium thermocouples at pit covers are sensing elements.

Want to apply these up-to-date control and instrumentation techniques to your industrial heating problem? Bristol engineers will be glad to talk over specific processes, problems, facts and figures with you. Write today to The Bristol Company, 106 Bristol Road, Waterbury, Conn.

**BRISTOL** POINTS THE WAY IN  
HUMAN-ENGINEERED  
INSTRUMENTATION  
AUTOMATIC CONTROLLING, RECORDING  
AND TELEMETERING INSTRUMENTS

# WAUKESHA casts all

# 3



## STAINLESS STEEL

- Group I — Martensitic
- Group II — Ferritic
- Group III — Austenitic

## NON-FERROUS

Monel Pure Nickel, Inconel  
Brass and Bronze, Aluminum  
Everdur, Aluminum Bronze

## WAUKESHA METAL

Copper Base, High Nickel Content  
Corrosion-Resisting Alloy. Developed  
and Produced Only by  
Waukesha Foundry Company.

## to meet your design needs...

• "Top" product designs and process equipment in every field require "top" castings.

Especially is this so where there is a critical corrosion-resistant casting design problem combined with one of hardness, or strength, elongation, wear resistance, bearing qualities, impact, scale resistance, seizing or galling, or intergranular corrosion among others.

Waukesha has the right metal and the casting ability to produce castings precisely to specifications... castings that stand up to the severe demands of today's designs and process equipment demands.

Metallurgical laboratory control guarantees you castings that are uniform, close-grained, free of porosity, metallurgically accurate in composition, and dimensionally correct—real assets to your products.

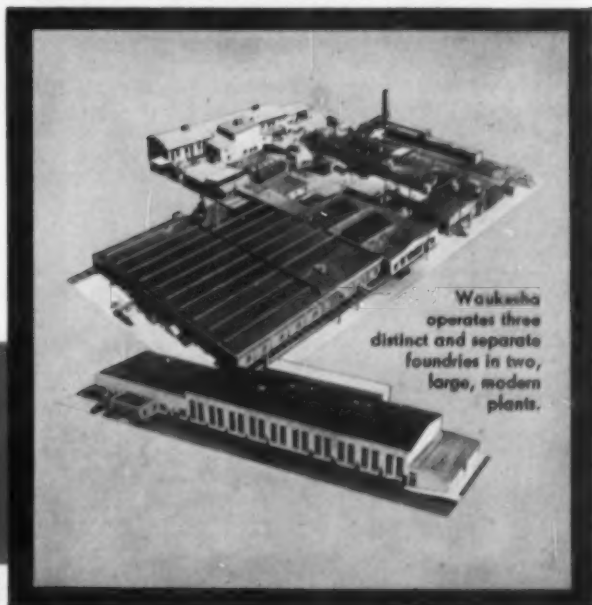
We suggest that you write for a casting quotation or engineering counsel.

**Waukesha Foundry Company,**  
5605 Lincoln Avenue, Waukesha, Wisconsin.

*Waukesha*  
Foundry Company  
WAUKESHA, WISCONSIN

WAUKESHA—SPECIALISTS IN  
CORROSION-RESISTANT CASTINGS FOR ALL INDUSTRIES

## in these modern facilities...



Waukesha  
operates three  
distinct and separate  
foundries in two,  
large, modern  
plants.

## Whatever your furnace needs for control—

There's good reason why more heat-treating furnaces everywhere are controlled by Brown instruments. First, of course, is performance... sensitive, precise control that meets the most exacting requirements of modern heat-treating techniques. And equally important is versatility. In this varied line of instrumentation you'll find just about everything a furnace could possibly need in the way of control.

Choose **ElectroniK Strip Chart Controllers** for detailed, long-term records... and a selection of control forms including electric systems of the contact, position-proportioning (*Electr-O-Line*) and time-proportioning (*Electr-O-Pulse*) types; and pneumatic control from two-position to full proportional-plus-reset-plus-rate action



Choose **ElectroniK Circular Chart Controllers** for ease of scale reading... convenient daily charts; in a full range of electric and pneumatic control forms.



*Note:* the basic components of all *ElectroniK* models are interchangeable... to simplify and speed up service.

Choose **ElectroniK Circular Scale Controllers** where you want readability and control check at extreme distance... without need for a record. Supplied with all contact and proportional types of electric control.



*Note:* all *ElectroniK* models are available in both Standard and Precision Series.

Choose **Pyr-O-Vane Controllers** where you don't need a record but do need precise vane type snap action electric control by a millivoltmeter instrument... also available with pulse-type time proportioning action, in both vertical and horizontal models.



Choose the **Protect-O-Vane Safety Cut-Off** for simple, dependable excess temperature protection... can be used with any temperature control to prevent furnace shut downs and loss of production.



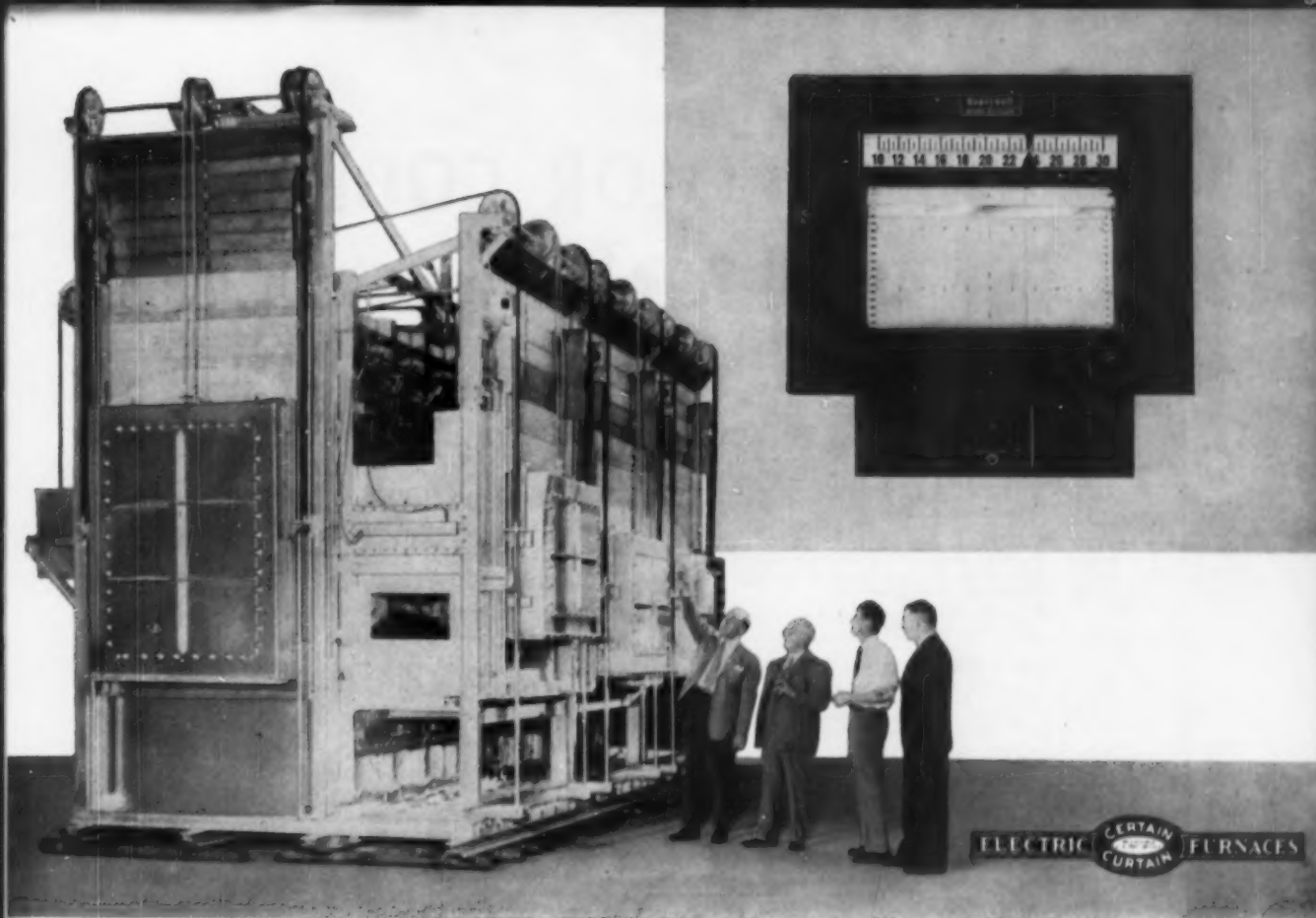
And for all your pyrometer supplies, investigate the convenience and economy advantages of the HSM Plan.

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1. Single colors are used for standard Carbon and Carbon Manganese Steels.
2. The colors GREEN, BLUE, YELLOW AND PINK always define Carbon content.
3. Centered dots of these Carbon colors always indicate the heat treated condition.
4. Centered dots of other than Carbon colors identify characteristics other than analysis, carbon content or the heat treated condition.
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KEY TO COLOR SYSTEM						
COLOR	CARBON STEEL BARS		ALLOY STEEL BARS			
GREEN	●	C 1018 - C 1020	①	Under .30 Carbon		
BLUE	●	C 1035	②	.30 to under .40 Carb.		⊗ Heat Treated
YELLOW	●	C 1042 - C 1045	③	.40 to under .50 Carb.		⊗ Treated
PINK	●	C 1095	④	.50 Carbon and over		⊗
PURPLE	●	Ledloy (Solid Purple) Lead Added (Purple Dot)	⑤	Rycut Series/Loaded		
BLACK	●		⑥	4100 Series		
WHITE	●	C 1212 - B 1112	⑦	4300 and 4600 Series		
ORANGE	●	C 1213 - B 1113	⑧	8600 and 8700 Series		
GOLD	●	Low Carbon—High Mang.	⑨	6100 and 9300 Series		
BROWN	●	Med. Carbon—High Mang.				
RED	●	C 1213 Acy. Stock (Solid Red) Sp'l. Ground Finish (Half Red)	⑩	Special Ground Finish		

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CARBON STEEL BARS				ALLOY STEEL BARS			
1000 Series	Ground Finish	Screw Stock	Med. Carb. High Mang.	RYCUT Series Loaded/Free Machining		Add'l. Alloys (Heat Tr.)	
GR	R	W	BR	P GR	P PK	Y	
C1018 C1020	C1213-11113 Acy.	C1212-11112	C1141	Rycut 20	New Rycut 50 Acid.	Ryzone	
B	R OR	O	Y	P Y	P O	ALY B	
C1035	C1098-C1025 T.G.&P.	C1213-11113	C1141 H.T.	Rycut 40 Acid.	New Rycut 50 H.T.	Ryzone T.G.&P.	
Y	R Y	GD	BR B	Y	P BR	Y W	
C1042 C1045	C1090-C1045 T.G.&P.	C1117	C1137	Rycut 45 H.T.	Rycut 50 Acid.	Nitrame M	
PK	R PK	P	GO	P OY	P GO	Y B	
C1095	C1141T &P C1141 Acy.	Leadloy C1117		Rycut 47 Acid.	Rycut 50 H.T.	Nitralloy 135 Mod.	

ALLOY STEEL BARS				CARBON STEEL BARS			
Loaded	4100 Series	4300, 4600 Series	8600, 8700 Series	O. H. Screw Stock	Med. Carb. High Mang.	Cold Dr. Stress R'd.	
P GR	BK Y	W GR	O GR	GD	BR	BR Y	
Loaded BR20	4140-4142 Acid.	4415 H.T.	8610	Ryzone	Ryzone	Stress-proof	
P Y	Y	W Y	O GR OR	Y	BR B	BR OY	
Loaded 4140-42 An.	4140 H.T.	4403 Acid.	8605	Loaded Ryzone	Ryzone T.G.&P./Acy.	Ryco 44	
Y	ALY B	W	GD PK	P	Y	B	
Loaded 4140 H.T.	4140 H.T. T.G.&P.	4300 H.T.	8610 Acid.	Ledloy	Ryco		

AIRCRAFT QUALITY ALLOY STEEL BARS									
BK	BK	BK	BK	BK	BK	BK	BK	BK	GD
B	B	B	B	B	B	B	B	B	GR
E4130 Acid.	E4130 Norm.	E4130 H.T.	E4130 H.T.	E4140 Acid.	E4140 Norm.	E4340 Acid.	E3740 Acid.	E9310 Acid.	

STEEL PLATES									
High Carbon	E-2-Cut	E-2-Cut	High C. E-2-Cut	Med. H. Abrasion Resisting	Full H. Abrasion Resisting	Low Alloy	E8615		

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KEY TO COLOR SYMBOLS:

A—ALUMINUM BK—BLACK GD—GOLD O—ORANGE PK—PINK W—WHITE  
B—BLUE BR—BROWN GR—GREEN P—PURPLE R—RED Y—YELLOW

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# Metal Progress

Volume 69, No. 6

June 1956

## Critical Points

By The EDITOR

### Physics, Metaphysics and Atomic Power

TO CHICAGO, pinch-hitting for Bill Eisenman in presenting a handsomely engrossed and framed charter to the newly formed Chicago-Western Chapter and, with 300 or more ASMembers, was delighted with the cordial hospitality of the staff at the Atomic Energy Commission's Argonne National Laboratory. The morning was occupied by a seminar on gases in metals, a standing-room-only affair, and there I engaged in a friendly argument with Larry Darken (one of the seminarists, and in private life assistant director of fundamental research for U.S. Steel Corp.). It might really be a problem in semantics.



He said that he didn't like the phrase "gases in metals", because hydrogen and nitrogen are not gaseous when they find themselves inside metals; furthermore he recommended that metallurgists might do well to put aside the mathematical "black magic" sometimes used to explain the observed effects—substituting for it the simple idea that the atoms of hydrogen or nitrogen merely combine with the imperfections in the lattice. Whereupon I likened him to Jean-Paul Sartre and chided him for substituting a new black magic for an old, for it would take a necromancer to explain to me how something can combine with nothing—but of course, as I said, it is merely that our static language of

spoken words has a hard time to keep up with the advances in metallurgical concepts (a difficulty less real, by the way, to one who understands the mathematician's language). What Darken meant to say was that the various natural imperfections in a "solid" metal—the vacancies within the crystalline lattice, the disregistry of atoms along slip planes, and the more complete disorganization at grain boundaries—provided natural lodging places for such stranger atoms wherein conditions were such as to attract and hold them.

S. S. Sidhu, senior physicist in the Argonne Metallurgy Division, also came up with another idea which startled us conventional thinkers: He has been studying three metal-hydrogen systems by neutron diffraction. The metals are zirconium, hafnium and titanium (all of which have identical electronic populations in the outer shells and therefore all should react in similar ways—as they do, but that is not the news). The hydrogen he used was the heavy isotope, deuterium, because it can diffract a neutron beam just as effectively as the heavy metals diffract an X-ray beam. In other words, he has a mechanism to discover how the hydrogen (or rather, the deuterium,  $D^2$ ) distributes itself in these three metals. The real solubility is *very* low—before more than a few atoms per million of deuterium get into the pure metal, the neutron diffraction pattern shows lines of a new phase, a cubic crystalline arrangement in the hexagonal metal. In hafnium it corresponds to a compound  $HfD_{1.628}$ ! Not  $HfD$  or  $Hf_2D_3$  or  $Hf_3D_4$  or  $HfD_2$ , but  $HfD_2$  minus  $D_{0.362}$  equals  $HfD_{1.628}$ . There goes our old chemical

fundamental, the stoichiometrical ratio! Maybe  $D_{0.362}$  is combined with a vacancy, or perhaps may even be a nothing! So that night I dreamed a dream wherein Metastability was hotly pursued by Metaphysics.

Two *bons mots* may be worth reporting: When asked a certain question about the metal uranium, Dr. Sidhu said, "Uranium is not a metal; it is a nightmare!" Again in answer to a question about the metallography of these hydrides (or deuterides) he said, "From my contacts with metallographers I have found them to be like clever patent attorneys — whatever I submitted to them for examination, they always saw more in it than I claimed myself!"

During the afternoon, while bus-loads of guests were touring various sites, the Editor had vivacious companions in Frank Foote and James Schumar, director and associate director of the metallurgy division, Carl Samans, director of metallurgy for Standard Oil Co. of Indiana and chairman of the Chicago Chapter, , Carl Swartz, consulting engineer and chairman of the Chicago-Western Chapter, , and A. B. Kinzel, vice-president (research) of Union Carbide and Carbon Corp. Norman Hilberry, deputy director of the Argonne National Laboratory also dropped in, as well as Merrill Scheil, chief metallurgist, and John Chyle, welding engineer for A. O. Smith Corp., so the talk got around to practicalities and how to lick dat ol' debbil hydrogen embrittlement, but without reaching much of any conclusion except that it was often difficult to say when a "brittle" fracture was due to lack of ductility in the metal or to undue restraint from the rest of the structure.

Consider this problem in design:


At Argonne a large steel cylinder, some 80 ft. diameter by 120 ft. high, with domed top, is being built to contain one of the power reactors in the A.E.C.'s five-year developmental program. Like the big sphere enclosing the submarine power reactor near Schenectady, it is designed to contain any radioactive particles resulting from an accident. Just one accident. In that unlikely event some rather high pressures might be generated, say 30 lb. gage.


Here's the question: Would you make this shield or container of thick plate and expect it to resist rigidly, or would you make it of thin plate and expect it to yield plastically? Or could you give it even more expansibility by building something like wavy wrinkles into it? How can you stop a shock wave which would start a crack? How give the steel or the shape enough plasticity

so it can deform plastically rather than shattering like glass?

It's an old problem, met in gun tubes, in pressure vessels and in hydraulic penstocks — an old problem, apparently still unsolved.

Talk also dwelt on the great interest in atomic power reactors by the public service corporations, despite the certainty that cost per kilowatt-hour would be considerably greater than from a modern steam plant. Here seem to be the reasons: (a) They will be strong impediments to large future increases in the price of coal. (b) Private industry wants to get started on its own and forestall a future government monopoly, a second Tennessee Valley Authority. (c) A large part of the power cost is from capital charges, but if there is further inflation, a high-priced power plant is better than money in the bank. (d) All the plants are being sponsored by cooperative groups of several large companies — the risk to any one firm is minor. (e) Finally is the cynic's view that the public service industry makes its money through the *distribution* facilities, and is comparatively insensitive to the raw cost of the thing it distributes.

At the  charter presentation dinner that same evening, Hilberry recalled that he was one of a group of physicists who started working under the grandstand at Stagg Field to find out if a chain reaction in uranium was possible. The name "metallurgical laboratory" was a perfect cover for this most hush-hush of war operations — it was something the trustees of the University of Chicago had talked about interminably but had never done anything about. Within a couple of weeks these physicists found they needed a chemist or two; a little later some mathematicians arrived; when they added medicos they thought the staff was well rounded out. Only a month or so later did they discover that metallurgists were also essential to the team — and the situation has never changed, for as Dr. Hilberry said, "We physicists can dream up and work out all the details of power reactors based on dozens of combinations of the essentials, but it's only a paper reactor until the metallurgist tells us whether it can be built and from what. Then only can we figure whether there is any hope that they can produce power at a price."

So it was easy for the Editor, in presenting the Chicago-Western charter to Chairman Swartz, to say that this new group and these young men had before them possibilities unlimited — which to my mind is one of the definitions of America. 

# The First Commercial Plant for Electrowinning of Chromium

By M. C. CAROSELLA and J. D. METTLER\*

Highest purity chromium is needed for superalloys, cermets and powder metal products. The new Marietta plant makes it from high-carbon ferrochromium — an electric furnace product — which is dissolved and 99.80% chromium electrodeposited in diaphragm cells from a chromium-alum solution. (C 23, Cr)

THE ELECTRO METALLURGICAL CO. and some of the other subsidiaries of Union Carbide and Carbon Corp. have been interested in chromium metal of high purity. "Electromet", of course, has a large interest in the production and sale of alloying metals as well as ferro-alloys, which interest dates back to the very formation of the company. Within the past 15 years there has grown a demand for chromium metal of hitherto unattainable purity for the formulation of low-iron alloys based on cobalt-chromium or nickel-chromium combinations suitable for oxidation and corrosion resistance, and for chromium carbide and cermets for high-temperature service. Furthermore, there seemed to be some possibility that ductile chromium metal could be produced, and this would open up a new area of interesting possibilities and engineering uses.

At the time, chromium metal could be and was being made by either electrothermic reduction by silicon or by aluminum, but the best of this product was fairly high in iron and silicon and these impurities could not be lowered substantially because they occur in the necessary raw materials of commercial grade. Consequently the Metals Research Laboratories turned attention to electrolytic processes. The fundamental ideas were that in an economical commercial process the source material must undergo some degree of purification or enrichment from the ore in order to eliminate a major portion of the impurities, and this beneficiated material must be in a form which can be dissolved easily.

Economic studies showed that the most readily available and cheapest source, free from many

extraneous elements, was high-carbon ferrochromium, a standard product of Electro Metallurgical Co. produced in the electric furnace. This alloy is readily soluble in sulphuric acid. Thus a new process evolved, combining standard electric furnace refining and electrolytic deposition into one integrated procedure to produce high-purity chromium from ore.

## Studies by U.S. Bureau of Mines

For many years the U.S. Bureau of Mines has studied the economic utilization of domestic chromium ores, substandard in grade, and the electrowinning of pure chromium from them. After the ore was roasted by the lime-soda process, a satisfactory chromium sulphate electrolyte could be prepared, but this scheme consumed too much costly chemicals. Further work by the Bureau at Boulder City, Nev., led in 1948 to a cyclic process wherein all the anolyte was consumed in dissolving the highly refractory chromite ores. Although technically sound, the many steps required to produce a sufficiently pure electrolyte rendered the process costly from both operating and construction viewpoints.

Meanwhile, in an independent investigation in our laboratories at Niagara Falls, a process for

\*A chapter (somewhat abridged) from the forthcoming book on Ductile Chromium and Its Alloys. The authors gratefully acknowledge the assistance of members of the Metals Research Laboratories, the operating department at Marietta, Ohio, and the metallurgical and engineering departments of the Electro Metallurgical Co. for their assistance in the preparation of this paper, as well as permission of the management to publish.

producing a pure electrolyte from high-carbon ferrochromium had been developed and patented (U.S. Patent 2,651,611). In this process sulphuric acid and excess reduced anolyte were used as a solvent. The solution, after being separated from the residue, was treated with a base for preferential precipitation of chromium as a basic sulphate containing only minor amounts of iron. This precipitate was dissolved in reduced anolyte to provide a satisfactory cell feed.

At about the same time (1950) R. R. Lloyd and his associates at the Bureau of Mines developed a comparatively simple and completely cyclic process which embodied the leaching of high-carbon ferrochromium with reduced anolyte and make-up sulphuric acid. Since the two research groups were proceeding along similar lines, the Electro Metallurgical Co. entered into a cooperative agreement with the Bureau of Mines wherein it was agreed that the Bureau would convert 6 tons of high-carbon ferrochromium to chromium in its pilot plant. It was also agreed that our engineers could observe the pilot plant in operation and that we would undertake to evaluate the marketability of the product by providing potential users with generous samples of the metal at no charge. In the end, practically every such user stated that electrolytic chromium was as good as or better than electrothermic chromium.

#### Materials of Construction

We then decided to build a pilot plant at Niagara Falls to perfect the process and obtain engineering information necessary to design a production plant. In addition to perfecting an operating cycle for a large commercial plant, later built at Marietta, Ohio, much of the pilot plant effort concerned the equipment and materials of construction. Hot solutions, very corro-

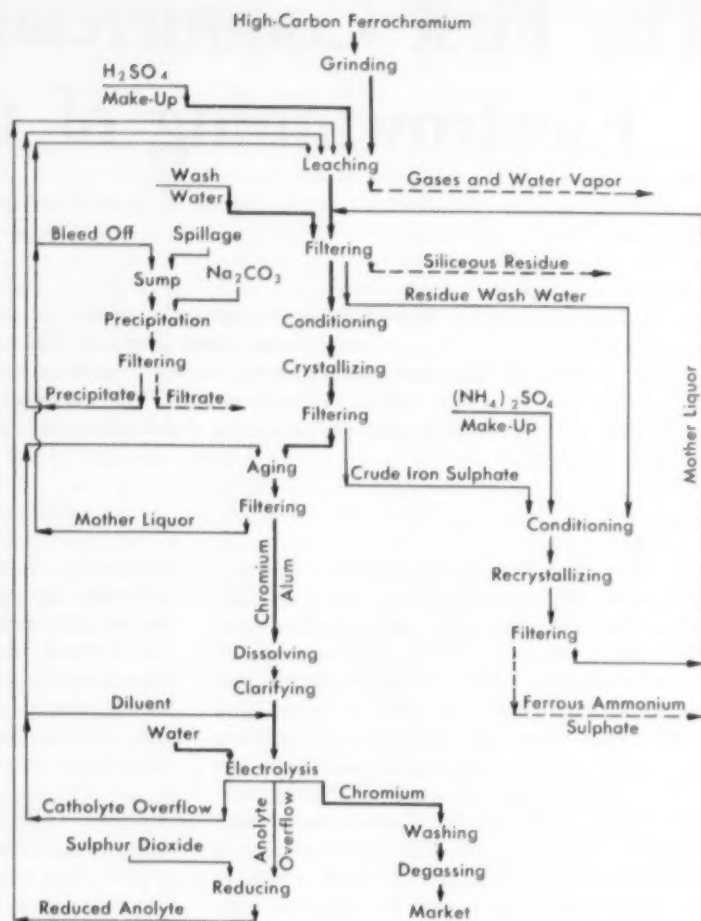


Fig. 1 — Flow Sheet of Marietta Plant for Making Electrolytic Chromium From High-Carbon Ferrochromium

sive and acidic and containing either strongly oxidizing or reducing salts, prevailed throughout the circuit. At the operating temperatures the use of plastics was limited. In addition to the tanks, we had to consider pumps, launders, hose, anodes and cathodes. The original cell and principal auxiliaries followed the designs used by the Bureau of Mines: Koroseal-lined steel was used for the tank, Lucite for the anolyte frames and associated internal parts, and wood for cathode frames and the necessary structural members.

Although Koroseal withstood the corrosive conditions at the prevailing temperature of 60° C. (140° F.), failure occurred at the bond between it and the steel, causing blisters which changed the cell dimensions and eventually permitted the solution to get into contact with the steel. Numer-

Table I - Typical Analysis of Solutions in Chemical Circuit

SOLUTION	COMPOSITION IN G. PER L.			
	Cr	Fe	NH <sub>3</sub>	FREE H <sub>2</sub> SO <sub>4</sub>
Leach filtrate	72	19	75	85
Residue wash water	4	2	2	4
Crude iron mother liquor	73	4	80	87
Ferrous ammonium sulphate mother liquor	35	7	80	5
Chromium-alum mother liquor	20	5	64	95
Cell feed	130	0.2	43	3

ous other coatings and plastics were tested, and finally glass cloth-reinforced polyester was found to meet the conditions of corrosion resistance and electrical insulation.

The anolyte frames are in contact with both the strongly acidic and oxidizing anolyte and the mildly acidic and strongly reducing catholyte. Lucite had fair corrosion resistance to both solutions. However, the frames and auxiliary parts softened at the 60° C. (140° F.) operating temperature which caused the anolyte frames to warp inwardly. This seriously affected operations because the diaphragms which were supported on these frames sagged and changed position. Molded and annealed polystyrene proved satisfactory against both corrosion and warpage.

Internal parts made of wood were satisfactory in the pilot cell. Plastic-impregnated wood was found to be more resistant to decomposition and was more dimensionally stable.

Extensive corrosion tests were made on a wide variety of alloys and metals in all of the plant solutions. Lead, silver-bearing lead, and Hastelloy C and D were the most resistant materials to the hot, strongly acidic leaching solution. In the relatively cool chromium-alum solution, Hastelloy A, B, C and D, nickel, Monel, Inconel, N-238 alloy, lead and silver-bearing lead were highly resistant. Hastelloy C, N-238 alloy, lead, silver-bearing lead and stainless steels offered the best resistance to the strongly oxidizing acidic anolyte solution.

Several solutions in this process vary widely from reducing to strongly oxidizing. Hastelloy C, lead and silver-bearing lead were the only materials that offered satisfactory corrosion resistance to all these different environments.

The effects of power interruptions on the cell were observed. Stoppages as short as 20 sec. caused sufficient re-solution at the metal surface to prevent resumption of plating when normal current was resumed. Any current interruption would therefore be quite disastrous in that the

cells would have to be shut down, drained and cleaned before operations could be resumed. It was also found that a minimum current density of 45 amp. per sq. ft. of cathode area was required to prevent the cathode deposit from dissolving at the normal operating pH level.

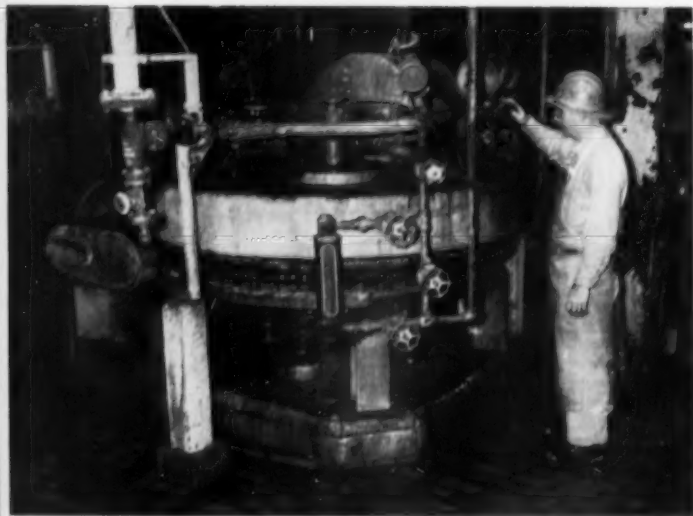
#### Commercial Plant at Marietta

When an analysis of the pilot plant operations at Boulder City and at Niagara Falls showed that the various factors were favorable, a commercial plant was designed to produce 2000 net tons of chromium per year. Actual construction at Marietta, Ohio, was started on May 8, 1951. Delivery of the many pieces of special equipment was slow and the leaching circuit was not started until Nov. 15, 1953. The first cells were started on Jan. 19, 1954.

The general flow sheet is shown in Fig. 1. The plant is housed in a single building, but because of the wide difference in the nature of operations carried out in the chemical and electrolytic portions, an effective separation of the two sections was made. It should be understood that the two circuits must of necessity operate as a unit, but for clarity the chemical and electrolytic portions are treated separately in the following description.

**Chemical Circuit** - A 3000-lb. batch of high-carbon ferrochromium, sized to pass through a 20-mesh screen, is fed slowly to a brick-lined, lead-protected steel leach tank where it is dissolved in a mixture of reduced anolyte, chromium-alum mother liquor and make-up sulphuric acid at a temperature near the boiling point. Leaching plus digestion time is 48 hr. per batch. During the reaction a large volume of hydrogen is liberated and a ventilating system, capable of maintaining hydrogen concentration below explosive limits, exhausts the gases to a scrubber. In this step evaporation is controlled to keep the volume of solution in the circuit in balance.

After leaching, the slurry is dropped into a holding tank where the cold mother liquor, coming from the ferrous ammonium sulphate crystallization, is added to cool the batch to 80° C. or lower (below 175° F.). The undissolved solids, consisting mostly of silica and less than 5% of the chromium in the feed, are separated from the solution in a rubber-covered filter. This residue is washed with water and discarded. The filtrate is advanced to a brick-lined, lead-protected steel conditioning tank, where the chromium is con-



*Fig. 2 - Acidproof Horizontal Filter to Separate Chromium-Alum From the Purification Circuit After Aging*

verted to the non-alum-forming modification by holding several hours at high temperatures.

This conditioned liquor is then pumped into a rubber-lined, batch-type crystallizer and the temperature is reduced to approximately 5° C. (40° F.) in 90 min. Crude iron sulphate crystals which are formed during this cooling period (containing 3.4% Cr, 6.5% Fe and 6.7%  $\text{NH}_3$ ) are separated from the mother liquor on an acidproof, drum vacuum filter. For good separation of iron it is necessary to feed the system well-conditioned liquor, to cool the solution in the crystallizer rapidly, and to filter before re-solution can occur.

*Fig. 3 - General View of Cell Room at Marietta*



Turning now to the treatment of the byproduct at this point, the solution resulting from washing the leach residue is used to dissolve the crude iron sulphate. Ammonium sulphate, equivalent to the amount discharged from the system with the ferrous ammonium sulphate crystals, is added to this solution and conditioned for several hours at elevated temperatures, and ferrous ammonium sulphate crystals then recovered in equipment similar to that used for the crude iron sulphate. This byproduct is dried in a rotary drier. Currently, a portion is being sold as a fertilizer for its ammonia content, and other uses for it are being developed.

Returning now to the main processing circuit, the mother liquor separated from the crude iron sulphate is clarified in an acidproof filter press and sent to the aging circuit. Aging takes place in steel thickeners lined with Koroseal. These tanks are designed to hold approximately 10 days' production of mother liquor, because the transformation rate of chromium from the green to violet or alum-forming modification is quite slow. Aging and crystallization are carried on at approximately 30° C. (85° F.). About 80% of the chromium is stripped as alum from the aging circuit. The crystal slurry is filtered and washed on an acidproof horizontal filter (Fig. 2). The filtrate is pumped to the leach circuit and the washed chromium-alum crystals (now analyzing 9.1% Cr, 0.01% Fe and 3.0%  $\text{NH}_3$ ) are dissolved in hot water to produce cell feed which is filtered prior to entering the electrolytic circuit.

Typical analyses of the various solutions in the chemical circuit are shown in Table I.

**Electrolytic Circuit** - Successful electrodeposition of chromium from chromium-alum solutions requires relatively narrow control of pH of the catholyte and preservation of the divalent chromium formed at the cathode. Sulphuric and chromic acids formed at the anode must be prevented from mixing with the catholyte in order to prevent oxidation of the divalent chromium and to maintain pH control. For this reason the cells are equipped with diaphragms of limited porosity which tend to prevent the anolyte from mixing with the catholyte. A further requisite is a rapid but nonturbulent flow of electrolyte over the cathode surface.

Although the physical design of the Marietta cells is similar to those developed by the Bureau of Mines, the materials of construction are completely different. The tanks, based on considerable testing of materials, are molded in one unit consisting of glass cloth laminated and bonded

with polyester resin. Anolyte in the cells is contained in internal frames and header boxes made of Bakelite's C-11 plastic. Cathode frames and internal supports are made of maple impregnated with plastic, our pilot plant having shown that this had longer life than untreated wood. Cells are cooled with coils made of Karbate tubing.

Figure 3 shows a general view of the cell room at Marietta, and it can be seen that the cells are covered and are strongly ventilated by induced draft, sufficient to reduce the hydrogen concentration well below its lower explosive limit and to lower the hexavalent chromium concentration in the cell room far below harmful limits to operating personnel. Exposure to toxic quantities of chromic acid or chromates causes dermatitis and deterioration of the mucous membranes. Long exposure to concentrations as low as 0.1 mg.  $\text{CrO}_3$  per cu.m. of air is considered toxic.

In the cell room the cells are arranged in two banks of 44 each. Direct current is supplied to each bank by a 10,000-amp. generator. Thus, two generators provide sufficient current for full plant operation. Because of the serious consequences of any electrical interruption, a spare generator is available which may be switched to either cell line.

Cell feed is supplied continuously to the operating cells. Since this liquid is quite viscous, even when hot, it is mixed with a stream of circulating catholyte to lower the chromium concentration. The amount of circulating catholyte must be kept to a minimum because, during circulation, the divalent chromium is oxidized, and this lowers the current efficiency. The flow of this mixture is regulated at each cell to maintain the chromium concentration within optimum limits. Quantity of feed to the circulating stream of catholyte and to each cell is adjusted according to chemical analyses made regularly.

The pH of the catholyte in each cell must also be controlled within narrow limits. This is accomplished by controlling the amount of catholyte flowing through the diaphragms into the anolyte chambers. Increasing this amount increases the ammonium ion concentration of the anolyte, and since ammonium ion can partly replace the hydrogen ion transference to the catholyte, this has the effect of lowering the hydrogen ion concentration or raising the pH. Decreasing the amount of catholyte entering the anolyte chamber has the opposite effect. An adjustable weir on the catholyte chamber is used to regulate the flow through the diaphragm. The sulphuric acid content of the anolyte in the cell is con-



Fig. 4 - A Portion of the Plate Handling Area

trolled at a concentration of 250 to 300 g. per l. by the addition of water to the anolyte chamber. When the acid concentration exceeds this limit, the diaphragms deteriorate and ultimately pH control is impossible.

Excess catholyte is withdrawn from the circulating stream and pumped back into the aging circuit. Anolyte is treated with sulphur dioxide in packed towers to reduce the chromic acid to trivalent chromium, and then returned to the head end of the ferrochromium leaching circuit. Complete reduction of chromic acid is necessary because high-carbon ferrochromium will not dissolve if oxidizing agents are present.

Cathodes of Type 316 stainless steel are withdrawn from the cells on a 72-hr. cycle. To avoid unduly upsetting the plating operation, one third of the cathodes are removed from each cell every day. The loaded cathodes are placed on racks and transported to the plate handling area (Fig. 4). Salt encrustations are dissolved in hot water. The brittle cathode deposit,  $\frac{1}{8}$  to  $\frac{1}{4}$  in. in thickness, is then stripped by a series of air hammers in a stripping machine.

The stripped metal is crushed to pass through a 2-in. screen in a set of rolls and further washed with hot water in a classifier to remove soluble salts. Washed and sized metal is discharged into stainless steel cans which are placed in an electrically heated furnace to dry and dehydrogenate the metal. The cooled metal is then packed in sealed drums for shipment. Front, back and fractured surfaces of typical specimens of the metal are shown in Fig. 5.

Stripped cathodes are then shot-blasted to clean and roughen the surface, straightened, degreased in a detergent bath, soaked in dilute sulphuric acid to dissolve entrained grit, dipped

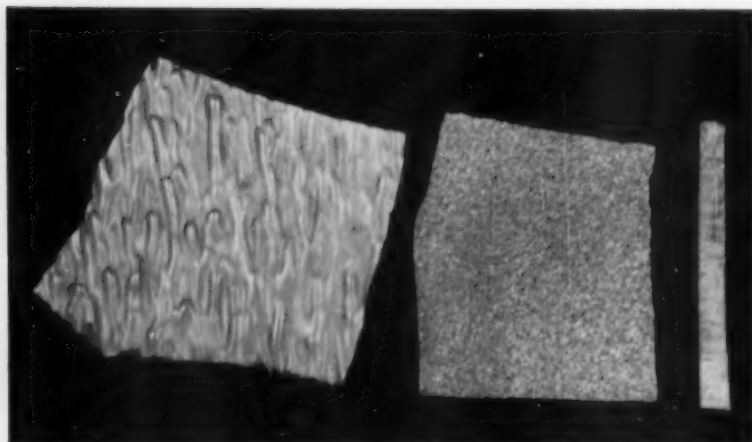


Fig. 5—Photograph of a Fragment of the Cathode Deposit, Front, Back and Fracture

in anolyte and rinsed with water. They are then ready for return to the cells. Such preparation is extremely important to the efficiency of cell operation. Improperly blasted cathodes may shed the deposit in the cell, which fouls the operation by re-solution. Warped cathodes cause uneven deposition and treeing. Clean surfaces are necessary to assure a complete initial strike and coverage. Typical cell operating data are as follows:

Cathode current density	70 amp. per sq. ft.
Cell potential	4.2 volts
Current efficiency	45%
Electrical consumption	8.4*
pH	2.1 to 2.4
Catholyte temperature	53±1° C. (125.5 to 129.2° F.)
Time of deposition	72 hr.
Cathode material	Type 316 stainless
Anode material	1-99 Ag-Pb

\*Kw-hr. of alternating current to motor generators per lb. of metal produced.

The current efficiency of 45% shown above represents an average for all operating cells in

the plant. Low efficiencies which always prevail during start-up of reconditioned cells are included. A pH range of 2.3 to 2.4 in the catholyte is preferred; lower pH decreases current efficiency. The 2.1 to 2.4-pH range used in the plant at Marietta results in a somewhat lower current efficiency but provides the necessary safe operating latitude. If the catholyte pH rises to 2.5 or higher, chromium precipitates in the cell and plating completely stops; the precipitate blinds the diaphragms and causes re-solution of plated metal. In order to restore plating conditions the cell then has to be shut down, drained, completely disassembled, and cleaned.

Materials of construction limit the operating temperature of the cell to a maximum of 60° C. (140° F.), and as noted above, the temperature of the catholyte is kept down by cooling coils.

#### Summary

The Electro Metallurgical Co. has been a commercial producer of electrolytic chromium since 1938, but only small quantities were made prior to the completion of the plant at Marietta early in 1954. Analyses of commercial chromium from the new and previous processes are shown in Table II.

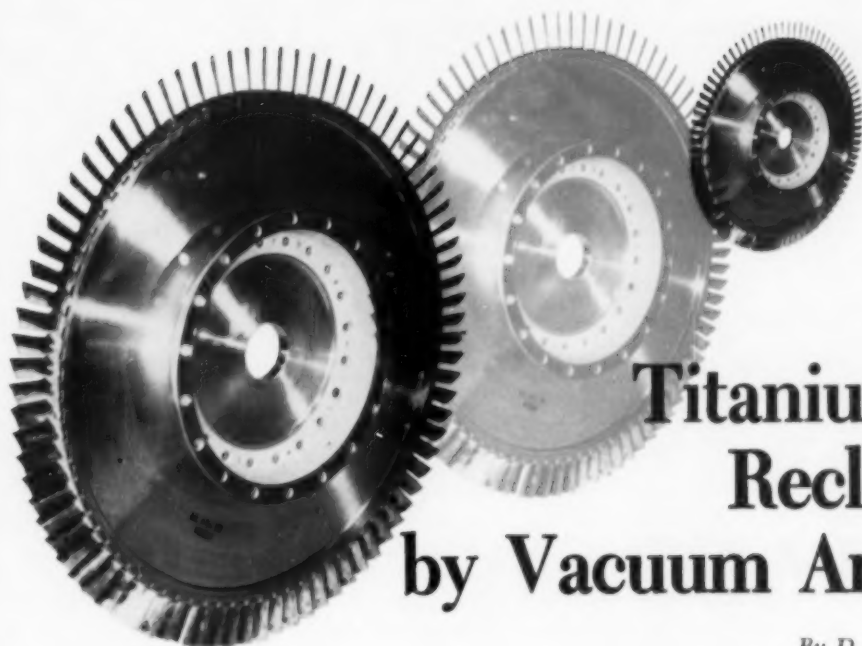
From the brief review given above, indicating that many types of special equipment are needed in carrying out the process, it should be apparent that plant costs as well as processing costs will always be considerable. It is very difficult to foresee any discoveries which will invalidate this statement. However, our research on this process has not stopped and we hope to make further improvements in the process, equipment, and in the quality of product. Several patents are pending as a result of recent discoveries.

Table II—Analyses of Commercial Chromium

ELEMENT	SOURCE OF METAL		
	ELECTROLYTIC*	SILICON†	ALUMINUM†
Cr	99.80	98.00	97.80
Fe	0.14	0.75	0.85
C	0.01	0.18	0.15
Si	Nil	0.60	0.50
P	Nil	0.03	0.02
S	0.025	0.008	0.018
Al	Nil	0.02	0.03 to 0.50
Mn	Nil	0.07	0.40
Cu	0.001	0.01	0.01
Pb	0.002	0.001	0.001

\*Metallic basis

†Reduction of chromium oxide



# Titanium Alloy Reclamation by Vacuum Annealing

By D. N. WILLIAMS,  
R. I. JAFFEE  
and C. A. BENTLEY, JR.\*

**Excessive hydrogen content can cause embrittlement and thermal instability of titanium alloys. Annealing in a vacuum furnace will reduce hydrogen contamination and restore ductility. (J 23, Ti)**

**T**HE RAPID expansion of titanium alloy production from a few hundred pounds in 1946 to several thousand tons in 1956 has caused many growing pains. Some were caused by production workers' unfamiliarity with the new materials, others by the inevitable inconsistency between lots of alloys produced in low volume. Time solved many of the problems but it was not until fairly recently that erratic ductility, delayed cracking, and thermal instability of titanium alloy components were traced to excessive hydrogen.

After the effects of hydrogen were determined, processing methods and controls were changed to avoid or minimize hydrogen absorption and the hydrogen content of titanium alloy parts is now consistently maintained at a safe low level. Unfortunately, millions of dollars worth of hydrogen-embrittled components had been scrapped and had to be reclaimed. A number of these components were reclaimed by vacuum

annealing to reduce the hydrogen content to a safe level.

The value of a vacuum annealing treatment may not always be immediately apparent. For example, a number of forged and stabilized Ti-140 A compressor wheels were rejected because the material failed to meet a minimum elongation specification of 15%. Rejection rates for these components varied from 27% to as high as 83%, depending on size. These wheels could be made ductile by heat treatment either in air or in vacuum, but vacuum treatment was found to

\*Dr. Williams and Dr. Jaffee are respectively assistant chief and chief of the nonferrous physical metallurgy division, Battelle Memorial Institute, Columbus, Ohio. Mr. Bentley is chief engineer, Kinetics, Inc., Hingham, Mass. Williams and Jaffee contributed the information on thermal stability from an investigation sponsored by the Aircraft Gas Turbine Div., General Electric Co. The description of production equipment was supplied by Mr. Bentley.

Table I—Thermal Stability of Ti-140A Forging

HEAT TREATMENT AND TEST CONDITION	ULTIMATE TENSILE STRENGTH	YIELD STRENGTH, 0.2% OFFSET	ELONGATION IN 4D	REDUCTION IN AREA	HYDROGEN CONTENT
As received	138,600 psi.	128,400 psi.	10.4%	12.0%	330 ppm.
1000 hr. at 350° F., stressed	140,800	133,000	9.5	11.2	330
200 hr. at 600° F.	141,600	136,400	0.5	1.0	330
200 hr. at 600° F., stressed	147,900	141,200	2.0	3.1	330
200 hr. at 800° F.	68,200	—	0.0	0.0	330
Heat treated in air	136,800	128,200	23.2	25.4	360
1000 hr. at 350° F., stressed	138,800	130,800	10.8	11.2	360
200 hr. at 600° F.	148,500	138,000	0.0	1.8	360
200 hr. at 600° F., stressed	144,000	—	0.0	0.8	360
200 hr. at 800° F.	71,800	—	0.0	0.0	360
Heat treated in vacuum	135,100	123,200	22.5	25.6	40
1000 hr. at 350° F., stressed	137,600	126,000	23.0	34.8	40
200 hr. at 600° F.	137,600	123,400	13.0	13.0	40
200 hr. at 600° F., stressed	137,300	126,200	18.8	24.5	40
200 hr. at 800° F.	144,400	125,600	12.0	13.2	40

have additional benefit in improving thermal stability and reducing strain-rate sensitivity.

Tangential bars were cut from the forged compressor wheels and heat treated in air and in vacuum. In either air or vacuum, the ductility could be restored by annealing for several hours at about 1550° F., furnace cooling to the stabilizing temperature, 1200° F., and holding for 1 to 4 hr. Thermal stability was checked by exposing tensile test specimens to one of the following test conditions:

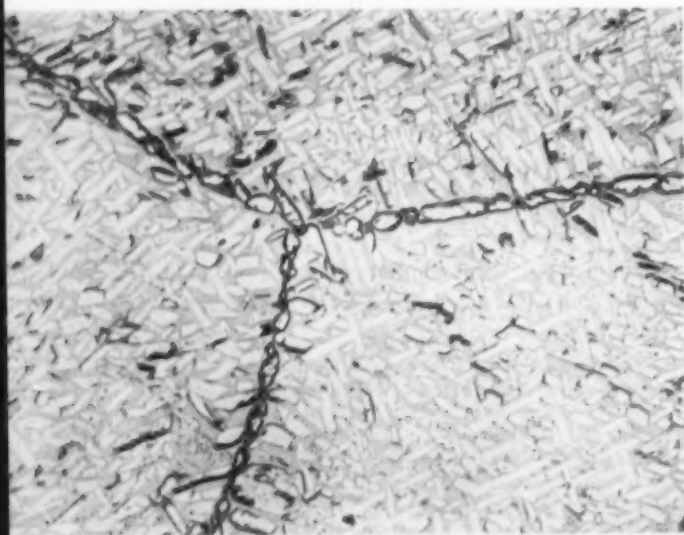
1. Stress of 50,000 psi. for 1000 hr. at 350° F.
2. Without stress for 200 hr. at 600° F.
3. Stress of 50,000 psi. for 200 hr. at 600° F.
4. Without stress for 200 hr. at 800° F.

The tensile properties after exposure are shown

in Table I. Both the as-received material and the material heat treated in air embrittled rapidly at 600 and 800° F. and there was a noticeable tendency toward embrittlement at 350° F. Heat treatment in vacuum, however, eliminated most of the instability. Presumably, this is due to the removal of hydrogen which accelerates the decomposition of the beta phase, since alpha-beta alloys, because they are not in equilibrium at low temperatures, have an inherent instability. However, it is possible that the instability noted in the high-hydrogen material was caused by the precipitation of a hydride.

The microstructure of Ti-140 A specimens heat treated in air and exposed for 200 hr. at 800° F. consisted of white alpha particles in a light gray beta matrix with a third dark gray phase which has not been identified. This phase does not appear in vacuum heat treated samples, and may be attributed to the increased instability caused by hydrogen. It was also seen in samples exposed at 600° F. but was not nearly so prevalent and did not reproduce intact on repolishing. Although the new phase appeared only in high-hydrogen material it was not possible to determine whether it was the product of normal beta decomposition accelerated by hydrogen, or a hydride.

High hydrogen contents embrittle alpha-beta titanium alloys in slow-speed tensile tests and static notch-rupture tests. The high-hydrogen Ti-140 A specimens were tested in a notched ( $K_t = 3$ ) stress-rupture test and failed in a brittle manner in about an hour or less when



Structure of Hydrogen-Contaminated  
Ti-140 A After 200 Hr. at 800° F.  
Nitric-hydrofluoric acid etch, 500×

*Titanium Alloy Blades Must Be Handled With Gloves to Prevent Fingerprint Stains*



loaded at 120,000 psi. Vacuum heat treated specimens could be loaded to 180,000 psi. and held for at least 6 hr. without failure.

It is apparent that hydrogen can promote both instability at elevated temperatures and marked strain rate and notch sensitivity at room temperature. Vacuum annealing of high-hydrogen titanium alloys (150 ppm. or greater) can, therefore, be expected to improve not only the low-temperature ductility properties of the alloy but also its thermal stability. This latter effect should prove highly desirable in many elevated-temperature applications.

Cost of vacuum heat treating of titanium parts in a solid state depends, of course, upon length of the cycle and temperature required and these in turn are determined by part sizes and whether they must be stress-relieved or degassed. Thin components such as blades evolve gas at a very fast rate. Thick forged parts such as compressor disks evolve gas more slowly and sometimes require up to 36 hr. at temperature for effective degassing.

As an average cost figure, compressor blades between 3 and 12 in. in length can be stress-relieved for from \$0.22 to \$1.35 per blade. Embrittled blades of the same size can be degassed and annealed, which requires a longer cycle, for from \$0.45 to \$3.30.

During the past year Kinetics Corp. has reclaimed over \$2,500,000 worth of hydrogen-embrittled titanium scrap by means of vacuum heat treatment. Most of it has been for jet engine and aircraft manufacturers and Kinetics' records show almost 100% success. Pieces reclaimed include finish-machined or semifinished titanium compressor rings, blades, tubing, sheet and wire. Much of the material came in as scrap worth 50¢ per pound, despite costly machining

operations, and went out as fully restored metal with greatly improved ductility and purity.

Degassing cycles may vary from 3 to 36 hr. at temperatures ranging from 1250 to 1800° F., depending upon the kind and amount of contamination of the metal treated. For example, three Ti-140 A jet engine disks weighing 72 lb. each were degassed by holding 36 hr. at 1250° F. under a vacuum of less than one micron. Gas was evolved rapidly during the first few hours of heat treating and pressure increased to about 600 $\mu$  and then decreased slowly. After 36 hr. at temperature the disks were cooled to below 500° F. in 3½ hr., the diffusion pump was shut off and the retort cooled with a fine water spray.

The vacuum-tight retort is an all-important part of the furnace system. It is subjected to temperatures up to 1800° F. and must resist scaling and frequent thermal shock. Inconel is used for both retort and fixtures because of its high-temperature strength and resistance to scaling. Some of our retorts are still in good condition after 5000 hr. of service.

In handling titanium, we have found that extreme caution must be taken to protect it against contamination. While loading and unloading the charge, workers must wear white gloves because finger prints are almost impossible to remove from titanium except by sand or vapor-blasting. The titanium parts tend to weld together at the degassing temperatures and they must be kept well apart with special Inconel fixtures.

Experience at Kinetics indicates that vacuum heat treating is an economical, indispensable method of degassing, annealing and stress-relieving titanium and titanium alloy parts. It is still a relatively new process in this country and it may find even greater use in improving the properties of other engineering alloys. ☐

# A Biographical Appreciation



Adolph O. Schaefer  
President, A.S.M., 1956

OUR president of the American Society for Metals has spent his entire working life with one organization. In the fall of 1922 when he joined the firm, a freshly graduated bachelor of chemical engineering from the University of Pennsylvania, it was called Midvale Steel & Ordnance Co. Shortly thereafter it became the Midvale Co., and only last winter the Midvale-Heppenstall Co. In these 34 years Ad Schaefer has steadily grown in responsibilities and in technical influence — the latter far beyond the steel and forge plant in the Nicetown suburb of North Philadelphia.

Back in 1922 when he was hired as research metallurgist he was assigned the "micro lab". The small staff, directed by Jim Adams, had the most varied assignments in melting, forging and heat treatment. One of Schaefer's most vivid recollections concerns the little induction melting furnace; it was one of the earliest, and was continually blowing the heating coil and filling the shed with a black cloud of mica and graphite insulation, through which he would grope to throw the switch. Another is getting heaved bodily out of Mike Furness's office — he was superintendent of the openhearth melt shop and he wasn't going to be told how to make steel by any college boy!

For the first 20 years (up to 1942) Schaefer was mostly in the test department, being engineer of tests for the last seven; a title which concealed the real duties, which were those of chief metallurgical engineer for production and sales. In these years he worked closely with Dr. H. L. Frevert, the president, from whom he had much encouragement and a free hand. There were many problems concerning the special products other than ordnance, such as toolsteels and bearing steels. During this time also there was a transition in pressure vessel and boiler construction from the large seamless drums in which Midvale specialized to welded plate construction. Development of large steam turbines and electrical generators, with a need for large rotor and spindle forgings, as well as Midvale's heat treated rolls for cold rolling mills, helped keep the large presses and furnaces busy.

Toward the end of this pre-war period, Schaefer devoted more and more of his time to the metallurgical advisory committee of U.S. Army Ordnance. When, in 1941, manufacture of big guns began in earnest, he was made chairman of the development group of the Gun Committee consisting of representatives of some 32 companies, forging gun tubes of 20-mm. caliber and

up. Its job was to prevent bottlenecks in production, anywhere. Eventually the 20-mm. guns were made from rolled bars or tubes, but even so the forging of larger artillery, recoil mechanisms, breech blocks, yokes and other parts involved many problems. Among them were the control of scarce alloy and cooperation with Great Britain, matters handled by committees with Quincy Bent of Bethlehem Steel Co. in the chair and on which Ad Schaefer served as operating or executive engineer for Midvale. (More recently, Midvale made the forgings for the first order of 280-mm. "atomic guns", described in *Metal Progress* for February 1953.)

Later in the war, when America started building jet aircraft engines, Schaefer was also appointed a member of the War Production Board's Superalloys Committee; his firm forged the first disks and has been quite active in this work ever since. He himself patented an austenitic Cr-Ni-W alloy composition for this service, but it actually has been of more use for high-temperature bolting stock.

During these years, Schaefer's title changed four or five times, and despite these time-consuming extracurricular activities, his duties at the Midvale steel plant continually increased in importance to include supervision of all technical matters and all engineering and metallurgy within the plant itself. The end of the war brought many difficult readjustments, not least of which were caused by a six-months strike. Gradually a new order was established, which involved not only a new line of products but many difficult transfers of supervisors and management. Through all these, Ad Schaefer's "inherent integrity" — as one of his former associates put it — stood him in good stead. "He was just as honest in those personal decisions as he was in innumerable technical ones. We could always depend on his taking the right side of a question. I doubt whether he has any enemies, even among those who may happen to dislike him for some reason or other."

In the late years Schaefer became vice-president in charge of engineering and manufacturing, and under his direction the openhearthers were modernized — Midvale still sticks to the acid process for making a superior steel — and a new roll shop built with its necessary heat treating equipment and lathes and other modern machine tools. While gun production went up in the Korean war, the principal output of large pieces is now heat treated alloy steel rolls, rotors and

spindles, heavy shafting, and high-alloy gas turbine forgings.

Schaefer spent many months in Europe studying the "full-fiber" forging process wherein the dies are moved sidewise by wedges pushed down by the descending ram. While a superior crankshaft can be made in this way, its web must be elliptical and this shape does not fit the American automotive designs, so the process was never exploited here. Midvale's consolidation with Heppenstall Co. integrates the above activities with a firm, nearly as old, manufacturing die blocks, rolls for tinning and galvanizing, rolled rings, and heavy handling equipment. Schaefer became director of research of the new firm.

Adolph Schaefer's forebears have lived in the Easton and Reading area since before the Revolution. He was born on March 5, 1901 in Phila-

delphia and raised in Bala. He married Jessie Rae Brooks, a neighboring girl. They have two children, a boy, Adolph Jr., who graduated in business engineering from the University of Pennsylvania and is now in the army, and a daughter, Gretchen, now studying at Briarcliffe. About 18 years ago he moved up country to "Broad Axe", a two-acre place north of Chestnut Hill, and he spends much time there, spring, summer and fall, "growing everything in the seed catalogue" in a characteristically engineering way, "to get a quarter-peck out of a pint-sized plot". His fruit trees are his pride and joy, but he ruefully admits they also seem as attractive to innumerable pests. All this prevents him from perfecting his golf game — much as he likes it.

One would think that the above would be enough, but no, Ad Schaefer has taken such an

## Russians Use Tagged Isotopes to Study Steelmaking

Radioactive elements used to study passage of stock through blast furnaces, wear of refractories, refining reactions in steelmaking and origin of inclusions in ball bearing steel. (S 19, D general, ST)



A MEETING of the Soviet Academy of Sciences was held in Moscow early in July of 1955 at which some 80 papers on "the use of atomic energy for peaceful purposes" were read in sessions lasting a full week and attended by about 2500 scientists, engineers and experts in various branches of industry and agriculture. Copies of some of these papers were distributed in official translation at the Geneva Conference, later in the year. One of them by A. M. Samarin, had the interesting title: "The Use of Artificially Radioactive Isotopes in the Study of the Processes of the Production of Steel and Iron". A large portion of this paper consisted of such general statements as "The staff at Zaporozhstal

has used radioactive indicators to ascertain with a greater degree of accuracy the duration of solidification of steel in the mold required to obtain an ingot with a proper macrostructure" — obviously not a very informative item of news.

Following are excerpts from Samarin's paper which are somewhat more specific:

### Blast Furnace Process


To investigate the movement of the charge down the shaft of the furnace, radioactive isotopes were introduced into the ore, coke, sinter and limestone, and the intensity of radioactivity measured by counters at various places around and down the shell, and then checked by deter-

active part in the Penn Alumni that he was awarded the 1954 Alumni Award of Merit, and a special citation at the University's 200th Anniversary. Of the Philadelphia Chapter , he was secretary-treasurer for seven years, its chairman in 1939, and recipient in 1954 of its award as "Man of the Year in the Delaware Valley". He was elected national trustee of  in 1953 and president in 1956. He has taken a particularly active part in Subcommittee VI on Steel Forgings of the American Society for Testing Materials and is a member of the advisory council of the parent Committee A-1 on Steel, and has been a director of the Society. Being also a member of the A.S.M.E. Boiler Code Committee, he is a natural choice for chairman of the task force studying brittle fracture of large forgings.

His associates say that "Ad's outstanding char-

acteristics are his kindliness, thoughtfulness and consideration for everyone he comes in contact with. Never, even in the most trying circumstances, have I seen him treat people in a manner that would transgress their self respect." Another writes: "He impresses me most, through all these years, as a man of complete serenity — an attitude which must derive from deep religious convictions. I say so because that's the way he lives; he never expresses them."

Still another: "No one ever has any doubts about him. He is thoroughly honest, and never lets personalities influence his decisions or acts. We all have unbounded confidence in his technical ability, for he evaluates complicated situations quickly and thoroughly."

Such is the president of the American Society for Metals, Adolph O. Schaefer. 

mining the characteristic radioactivities in the pig iron and slag.

It was found that the speed of transit can be controlled within a wide range by changing various factors. The burden moves downward at a faster rate along the vertical axis of the shaft than at the periphery.

Upward movement of gases was investigated by introducing through one tuyere a radioactive inert gas and detecting its movement as noted above. Velocity of gas through a blast furnace with a shaft volume of 40,000 cu.ft. is 72 to 79 ft. per sec.

Since 1951 many plants in the U.S.S.R. have used small capsules of radioactive cobalt ( $\text{Co}^{60}$ ) to measure wear of hearth walls of blast furnaces. Such capsules would be placed at various depths from the inner face of the hearth wall — say 6 in., 16 in. and 30 in. from the face — such groups being placed at 120° in the horizontal cross section at strategic elevations, whereupon the wear is judged either by the appearance of  $\text{Co}^{60}$  in the pig iron or by measuring (outside the furnace) the intensity of the remaining radiation

#### Desulphurization

The kinetics of desulphurization have been investigated with the aid of radioactive sulphur isotope  $\text{S}^{35}$  in soda ash and in a slag consisting of calcium oxide and alumina. It reveals the possibility of driving down the sulphur with either reagent until the iron contains less than 0.001%.

Speed of desulphurization is proportionate to the concentration of sulphur in the metal, and this rate can double as the temperature goes up. This influence of temperature leads to the assumption that the limiting factor in commercial desulphurization is the transfer of sulphur by diffusion through nonmixing layers in the liquid slag.

Other investigations had to do with the absorption of sulphur by molten metal from the atmosphere of openhearth furnaces at various stages in the heat. During melting some 10 to 20% of the sulphur contained in the hot gases passes into the metal; at the same time some sulphur passes from the charge into the gas, though to a lesser extent. Combustion air enriched with oxygen increases the speed of melting a cold metal charge and thus helps in obtaining metal with a lower sulphur content. In the refining period but 1% of the sulphur contained in the atmosphere of the furnace passes into the metal.

#### Openhearth Operations

Improvements in equipment for the detection of radioactivity in metal and slag have enabled us to reduce considerably the amounts of isotopes necessary for tests on full-scale furnace heats. For example, it has been established that radioactive cobalt placed on the furnace bottom in front of the middle door in a 350-ton openhearth furnace is evenly distributed throughout the bath within 10 to 20 min. during the period of rapid

decarbonization. When this addition was made through the end door, the time required for even distribution of small additions in 24-ton, 50-ton and 350-ton openhearth furnaces is 10, 45, and 55 min. respectively.

Thus the spreading of small additions in liquid metal is by turbulent diffusion, rather than molecular diffusion, since the mass transfer in liquid iron calculated on the basis of the above experiments is millions of times faster than the coefficient of molecular diffusion.

Coefficients of mass transfer have also been determined in openhearth and electric arc furnaces of various capacities, using radioactive isotopes of chromium, tungsten and sulphur. For example, it has been found that a piece of ferrochromium weighing 45 lb., placed in a 190-ton openhearth furnace, is completely melted in 10 to 20 min.

**Cold Metal Melting** — A study of slag formation required some information about the speed of melting of the cold metal. To do this radioactive isotopes of iron or cobalt were placed in the last ladle of liquid pig iron poured into the furnace. The speed of melting scrap could then be determined by the decrease in intensity of radiation of the metal samples taken from the furnace, as they became diluted with the metal already in the furnace. Naturally, the speed de-

pends on many factors, particularly important being the temperature control, the condition of the bath after adding the liquid pig iron, and the time when interaction between the pig iron and iron ore ceases.

In order to study the interaction between iron ore and metal,  $\text{Fe}^{59}$ , a radioactive isotope of iron (as oxide), was mixed with the ore and charged at various horizons. When ore and limestone are successively added as ore-limestone-ore in a 100-ton openhearth furnace, the upper layer of the ore starts to react with the liquid pig iron 20 to 30 min. after melting begins, and the lower layer of ore in 60 to 90 min., that is after flushing the primary slag from the furnace. In other words, the iron ore charged under the limestone takes little part in the interaction between metal and slag, and notably in the dephosphorization.

**Dephosphorization** — The phosphorus isotope,  $\text{P}^{32}$ , placed on the bottom of a 30-ton furnace in the period of intensive boiling is rapidly and evenly distributed through the metal and slag. The kinetic curves in Fig. 1 indicate that in the above conditions approximate equilibrium of phosphorus distribution is achieved in 30 to 40 min. after melting the charge. This is followed by a slow rephosphorization resulting from rising temperature.

Plotting the data in semi-logarithmic coordinates shows that the dephosphorization rate is proportionate to the concentration of phosphorus in the metal. This finding has led to a rational technology for obtaining slag of high phosphorus suitable as a fertilizer.

The positive role that the slag which remains in the furnace after tapping the heat plays in the formation of slag in the subsequent heat has been revealed, as well as in the dephosphorization of the metal during the melting period.

#### Inclusions in Steel

Production of steel with minimum nonmetallic inclusions requires reliable data on the origin of these inclusions, and it is practically impossible to determine their source by chemical analysis or by metallographic examination. One cannot assert, for instance, that a particle of aluminum silicate results from deoxidation reactions with silicon and aluminum, since it could easily be a particle of slag, of refractory material from the furnace lining, or of the ladle.

Radioactive indicators, however, can "tag" all the materials and thus determine the influence of every source separately. For example, we have made quantitative determinations of the con-

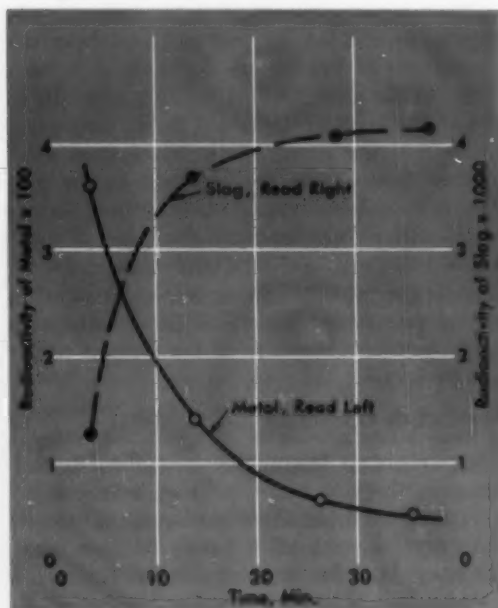


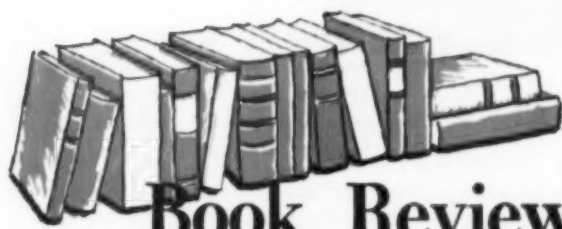
Fig. 1 — Distribution of Phosphorus With Time Between Metal and Slag During Openhearth Heat as Determined With the Phosphorus Isotope,  $\text{P}^{32}$

tamination of steel from its containers during tapping and pouring. The radioactive isotope of calcium,  $\text{Ca}^{45}$ , as  $\text{CaCO}_3$  and  $\text{CaO}$ , was used.

A special study by such means of ball bearing steel made in either acid or basic electric furnace shows that slag formed in the reduction period is blameless in this respect. If the steel is bottom poured, about 10% of the nonmetallics come from the nozzle, and another 20% from erosion of the ladle lining. The latter also depends upon

the character of the refractories; chamotte brick will introduce two to two and a half times as much as a high-alumina brick.

Radiographs made from sectioned ingots show that nonmetallic inclusions are not displaced by growing crystals when the ingot solidifies. Inclusions in the melt are captured by branches of the growing metallic crystals, and this capture is strongly influenced by "interphase tension" and also by the linear speed of crystalline growth. ☐



## Book Review...

### Titanium Research Manual

*Reviewed by HAROLD MARGOLIN\**

METALLURGY OF THE RARER METALS,  
No. 4 — TITANIUM, by A. D. McQuillan  
and M. K. McQuillan, Academic Press  
Inc., New York, 1956, 466 p., \$10.

The low activation energy for research in titanium, resulting from considerable United States government financial support, has produced an enormous amount of information on this metal in the last decade. The authors have set themselves the formidable task of assembling and evaluating the broad spectrum of published data. Their principal interest, however, is the basic properties of titanium and its alloys and they have included sections on industrial technology because it "is unusually dependent on the fundamental nature of the metal".

The authors' approach in dealing with each research subject has been to present the available information in rather considerable detail and then evaluate it. When technology is considered, the problems involved are given, solutions as they have developed are presented and discussed in terms of metallurgical principles. The result is a

\*Engineering Scientist, New York University.

scholarly book, well written and easily read.

The authors' own research work has largely been concerned with phase equilibria and alloy theory, and more than 25% of the book is devoted to constitution diagrams. Their findings have not agreed with results obtained in this country principally in relation to the positioning of eutectoid temperatures and phase boundaries between beta and alpha-plus-beta fields. The authors have used the results of their own work in evaluating constitution and TTT-diagrams. Recent studies at New York University suggest that the McQuillans are generally correct in their interpretation.

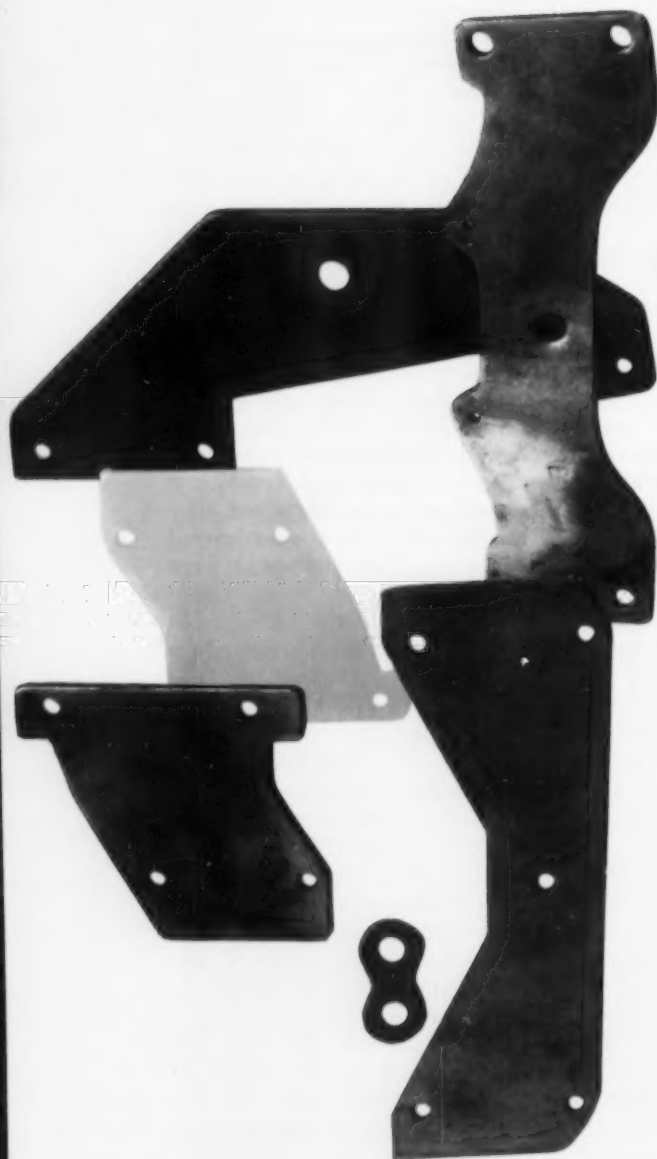
It is inevitable that this book should bring to mind the Titanium Metallurgical Laboratory reports being issued by Battelle Memorial Institute. The Battelle group is more interested in practical metallurgy, and its reports usually present more data on a specific subject than appears in this book. On the other hand, the McQuillans have devoted considerable space to fundamental metallurgy, metal production and fabrication and phase diagrams, subjects which are not as yet covered by Titanium Metallurgy Laboratory reports. The difference in emphasis makes the book and the reports logical supplements.

In summary we can say that this should become an indispensable reference book for the research metallurgist in the titanium field. ☐

# Descaling Steel Sheet by Shot-Blasting

By WILHELM OLSON\*

Shot-blast descaling of hot rolled low-carbon steel sheet and strip has not only relieved a procurement problem but has also reduced costs.  
(L 10, CN)



*Representative Automotive Hardware Produced in High Volume From Hot Rolled Steel*

**T**HE COSTS of extremely competitive, high-volume metal components such as automotive hardware are calculated very closely and production is profitable only when steady and uninterrupted. Most of the hardware is made from hot rolled low-carbon steel and strip, pickled and oiled by the producer. When business is good, the material is scarce and difficult to obtain in the uniform quality required for forming operations. Unpickled steel is often easier to obtain but the scale from it is abrasive and shortens die life considerably.

With the increase in automobile production to record levels, steel mill pickling facilities became inadequate and we were forced to purchase a greater proportion of unpickled material to maintain production. At first, we reshipped it to a separate pickling plant for reprocessing but the extra cost of double handling and shipment was prohibitively expensive. In addition, more storage space was required, under cover, for pickled steel, and outdoors for the unpickled material.

After an exhaustive cost analysis, it became obvious that the steel should be descaled in our

\*Metallurgist, Atwood Vacuum Machine Co., Rockford, Ill.

*Interior Storage Area  
Required for Pickled  
or Shot-Blasted Steel*



own plant. A pickling installation could not be justified on the basis of space requirements and operating costs and the most economical solution was a continuous shot-blasting machine. The equipment is a Wheelabrator belt-conveyer machine and includes an outdoor roller conveyer, a hoisting table and positioner, a series of straightening rolls, the blasting cabinet, exhaust system, oiling cabinet and a restacking and strapping table.


All stock as received is stored outdoors. It is brought to the conveyer by a yard truck equipped with a hydraulic grip. Bundles are transferred to the loading table where suction cups lift one sheet at a time which is placed on the conveyer by a ram hook. If straightening is required, the rolls can be adjusted to suit; if not, they are separated to allow free movement of the sheets to the blast cabinet. Average belt speed is about 30 ft. per min. and the capacity of the unit is about 240 sq. ft. per min. Both sides of the sheet are blasted at the same time.

When the process was first installed, there naturally were problems to be worked out. Shot-blasting intensity had to be controlled within reasonably close limits which could be determined only by experience. For instance, if travel speed is too rapid, or if blasting grit is not replenished properly, scale may not be removed thoroughly. A little residual scale may do no harm in press operations but does cause finishing problems. Automotive hardware is either zinc-plated or painted and neither finish will adhere properly to scaled surfaces.

If blasting is too heavy or the grit too coarse, surface finish will be so rough that parts will

seize and tear in forming and drawing operations. Proper blasting creates just enough roughness to hold a uniform film of lubricant; excessive roughness causes high ridges that result in metal-to-metal contact under the high pressures required in press operations. Extra heavy blasting will also increase hardness as a result of cold working and reduce drawability of the material. Chilled shot of Rockwell 45 to 50 hardness, 110 mesh per in., is used. Replenishment is at the rate of 35 lb. per hr.

Lower cost is the primary advantage of the shot-blast process; in addition, scheduling and handling are much more convenient. Bundles as received are now stored outdoors, thus saving valuable heated space. Only shot-blasted steel must be protected from the weather. Handling costs are lower outdoors than inside; however, there are times when ice will form between sheets stored outside. When that happens, the previously mentioned suction cups fail to lift the sheets, making it necessary to separate them manually. One man can handle bundles from an enclosed cab outside whereas a crane operator and floor man are needed to move steel indoors.

All of the above advantages are incidental. The greatest benefit of all is the direct saving of \$4 per ton over pickling cost. This figure, multiplied hundreds of times a month, makes this shot-blasting unit a very worthwhile investment. Additional savings are possible. Hot rolled steel may be purchased in coils, flattened and shot-blasted. It can then be cut into sheets, or slit to blanking width and recoiled. Not only will material costs be lower, but slitting will also reduce the cost of the blanking operation. 

# Experience With High-Manganese Stainless Steels

By RICHARD E. PARET\*

Newly standardized Types 201 and 202 should save much nickel, for they match most of the properties of 18-8 in sheet form. Seldom are changes in tooling necessary in the usual fabrication operations. (SS)

**I**NCREASING demands for austenitic stainless steels and a continuing shortage of nickel for "nondefense" purposes have led producers to seek various means of stretching the available nickel. One solution has been the development and acceptance of the new low-nickel, high-manganese types.

The function of nickel in stainless steel is to form austenite and retard its transformation to martensite during cold working operations. It also has a significant cumulative effect on corrosion resistance in the presence of chromium. Both manganese and nitrogen serve much the same austenite-stabilizing function as nickel and a combination of the two may be more effective than nickel in retarding austenitic transformation during cold work. Chromium is the essential alloy of all stainless steels since it is the only element capable of producing stainless characteristics in iron.

\*Committee of Stainless Steel Producers, American Iron and Steel Institute, New York. Fourth in a series; previous articles appeared in *Metal Progress* in December 1955 and February and May 1956.

For more than 20 years, the possibility of replacing some of the nickel in conventional stainless steels with manganese has been studied extensively. Considerable attention was also given the matter by European metallurgists. The first commercial use of such an alloy in America was during World War II when a stainless with 17% Cr, 4% Ni and 4% Mn was substituted for 18-8 Cr-Ni steel primarily in transportation equipment. There were some difficulties with this composition due to excessive breakage in cold forming operations which was associated with the high work hardening rate.

During the Korean Emergency, Schedule A of N.P.A. Order M-80 limited the use of nickel in most civilian goods to a maximum of 1%. This resulted in the production of a stainless alloy nominally composed of 15% Cr, 1% Ni and 17% Mn. Although its mechanical properties were comparable to those of A.I.S.I. Type 301 (17-7), its corrosion resistance and hot working characteristics were inferior. Today, alloys of this general composition with higher nitrogen contents are under study and show great promise.



Fig. 1 — Stainless Steel Trailers Have Been Made at the Budd Co. of Types 201 and 301 With no Noticeable Difference in Fabrication

The new A.I.S.I. Types 201 and 202 are a direct outgrowth of previous experience with low-nickel high-manganese steels. They are evolutionary, not revolutionary, and have a background in production and service which offers the metalworking industry alloys of merit with wide potential application. They are the first of the low-nickel austenitic stainless steels to be

standardized and as such are a new family of stainless steels — not merely substitutes designed to meet an immediate emergency. Composition ranges are:

	TYPE 201	TYPE 202
Chromium	16 to 18%	17 to 19
Nickel	3.5 to 5.5	4 to 6
Manganese	5.5 to 7.5	7.5 to 10.0
Carbon	0.15 max.	0.15 max.

Table I—Typical Mechanical Properties of Sheet Material

PROPERTY	STAINLESS TYPE			
	201	301	202	302
Yield strength, psi.*	55,000	40,000	55,000	40,000
Tensile strength, psi.	115,000	110,000	105,000	90,000
Elongation in 2 in., %	55	60	55	50
Rockwell hardness	B-90	B-85	B-90	B-85

\*0.2% offset.

Control of nitrogen content is an important factor in the production of these steels and a maximum of 0.25% is specified. Higher quantities are unnecessary and may, in some instances, affect melting and processing techniques, and mechanical properties. Current production analyses usually are in the range of 0.10 to 0.20% nitrogen.

Types 201 and 202 presented a num-

Table II—Corrosion Resistance in Formaldehyde Solutions

TEST CONDITIONS				PENETRATION, IN. PER YEAR*			
% FORMALDEHYDE	TEMP.	DURATION	AERATION	TYPE 202	TYPE 304	TYPE 410	TYPE 430
22.8	878° F.	63 days	Yes	<0.0001 (d)	0.0001 (e)	0.0007 (e, d)	0.0001 (e, d)
35	185	212	Yes	<0.0001	<0.0001	0.0002 (e)	<0.0001 (c)
35	185	212	No	<0.0001	<0.0001	0.0017 (f)	<0.0001 (e)
39	235	244	No	<0.0001 (e)	<0.0001 (c)	0.0006 (e, c)	<0.0001
37 to 48	120	189	Yes	<0.0001	<0.0001	<0.0001	<0.0001

\* (c) crevice corrosion, (d) discoloration, (e) etching, (f) corroded.

ber of problems in manufacture, most of which have been solved. Because of their higher strength, greater power is needed in initial break-down of the ingot. A blooming mill operating at maximum capacity on Type 301 could not, for example, handle the same size ingot made of Type 201.

Stainless steel producers request that Type 201 and 202 scrap be segregated for maximum alloy recovery and to prevent any difficulty in controlling manganese content of high-nickel austenitic steels. It is possible to recover as much as 85% manganese and 90% chromium from the scrap by back-charging it near the end of the reducing period. For example, carbon steel and low-manganese stainless scrap (300 and 400 series) totaling perhaps 60% of the charge are melted and the heat blown with oxygen to reduce carbon below 0.10%. During this oxidizing period nearly all the chromium oxidizes and goes into the slag. Additions of chromium-silicon or manganese-silicon ferro-alloys then reduce much of this chromium oxide; the 201 and 202 scrap is added and the heat brought back to temperature. Necessary additions of chromium and manganese alloys are made to produce the desired composition and the heat finally deoxidized with a lime-alumina slag. When high-manganese scrap is melted down initially, the oxidation of chromium and manganese will reduce recovery to as low as 30% of the manganese and 75% of the chromium.

The number and extent of finishing operations performed on stainless, unique among ferrous products, need not be varied to accommodate Types 201 and 202. No difficulties have been reported nor are there any substantial differences in surface appearance as compared to corresponding Type 300 grades.

Typical mechanical properties of Types 201 and 202 sheet material in 2 B finish are given in Table I with comparison values for Types 301 and 302.

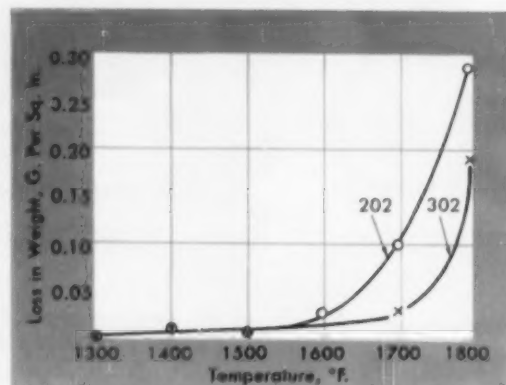


Fig. 2—Scaling Tests on Types 202 and 302 Stainless

In general, the corrosion resistance of Types 201 and 202 is approximately the same as that of Types 301 and 302. To date, every test application of the Cr-Ni-Mn steels has proved satisfactory in such uses as cooking utensils, sinks, restaurant equipment and transportation equipment. There is every indication that these steels can replace Types 301 (17-7) and 302 (18-9) in any application where the latter are being properly used. While they are not generally

Table III—Elevated-Temperature Properties

TYPE	TEST TEMP.	STRESS FOR RUPTURE, PSI.	
		1,000 HR.	10,000 HR.*
201	1200° F.	21,000	14,500
201	1400	7,000	3,600
202	1200	23,500	18,000
202	1350	10,500	7,000
304	1200	17,000	10,500
304	1350	7,500	4,500
304	1400	7,000	4,000
347	1200	22,500	17,500
347	1350	10,000	7,500
347	1400	8,000	6,000

\* Extrapolated values.

Fig. 3 — Round Processor for Dairy Industry Made of Type 202



recommended as replacements for Type 304 (19-10), there may be instances where steel specifications are "over-alloyed" and the low-nickel austenitic types may be able to perform satisfactorily. Typical are certain dairy equipment items which were previously specified in Type 304 and then subsequently changed to Type 302.

For a number of corrosive chemicals laboratory short-time tests have indicated no appreciable difference between the high-nickel and the low-nickel steels. These include solutions of 5% lactic acid, 10% phosphoric acid, 60% acetic acid, 5% sulphuric acid and 2% hydrochloric acid. The results of field tests in formaldehyde solutions indicate that Type 202 is as resistant to corrosion as Type 304 (see Table II).

The scaling resistance of the Cr-Ni-Mn steels is equivalent to that of Types 301 and 302 up to approximately 1550° F., as shown in Fig. 2. At higher temperatures scaling proceeds more rapidly, so that annealing temperatures should be lowered by 50 to 100° F. to reduce difficulties in pickling. To prevent any chance of over-pickling in a nitric-hydrofluoric bath, hydrofluoric concentration can be decreased and pickling temperature lowered 10 to 20° F.

The rate of work hardening of the Cr-Ni-Mn grades is about the same as that of the comparable chromium-nickel types. Composition balance is the controlling factor and variations from heat to heat are to be expected. In the

newer Cr-Ni-Mn types somewhat greater variations may be expected, and in any development program samples from different heats should be tested for their production potentialities.

Experience to date has shown that the Cr-Ni-Mn types can be expected to respond much the same as chromium-nickel grades in both shallow and deep draws. Difference in work hardening has not been sufficient in any instance to require additional annealing or a modification in depth or rate of draw. The higher strength of the low-nickel types has proved to be of definite advantage in some drawing operations and certain specialized production practices.

Limited test data have indicated that the modulus of elasticity of the Cr-Ni-Mn stainless steels is 28,600,000 psi. — slightly higher than the 28,000,000-psi. modulus of the Cr-Ni steels.

At elevated temperatures, the short-time tensile and creep-rupture properties of Types 201 and 202 are superior to those of Types 301 and 302 and compare favorably with those of Type 347 (stabilized 18-10). See Table III.

The number of applications for these new alloys is steadily increasing. Change in the tooling or techniques used for the high-nickel alloys has seldom been required. Successful fabrication processes include welding, drawing, simple machining, soldering, stamping, polishing and flash plating with chromium. The growth in usage should increase more rapidly as more service experience is gained.

# Effect of Molybdenum in Iron and Steel

By ALVIN J. HERZIG\*

During the period in which William Park Woodside was active in research, the art of heat treatment developed into a science and much was learned of the effect of molybdenum on the properties of steel and cast iron. (J 26, Q general, Mo, CI, AY)

**H** EAT treatment was of major interest to William Park Woodside, and under his guidance much of the research effort at our laboratory was devoted to studies of how and why steels behave as they do when heated and cooled. At the time of his retirement in 1943, the old cut-and-try methods of determining the best heat treating cycles had been virtually abandoned and the use of hardenability for steel selection and heat treatment was in general use. Our contributions to the science of heat treating were only a small part of the industry-wide effort but our definitive studies on the effect of molybdenum as an alloying element proved to be most useful when conservation of other more critical alloying elements ultimately became necessary.

In the middle 1930's we were all faced with the necessity of revising our theory on the

mechanism of the transformation of austenite. The adequacy of the Sauveur theory of hardening was being challenged by the time, temperature and transformation studies of E. C. Bain and E. S. Davenport. Whereas we had in the past been quenching and tempering steels in  $\frac{1}{4}$  to 12-in. rounds and making countless hardness surveys to determine the capacity of various compositions to harden, we were at last provided with the Jominy end-quench test.

## Early Studies on Hardenability

These two developments had a profound effect on the type of information the alloy steel consumer sought. The trend away from the purchase of steels by chemical composition only, which trend had begun with the specification of grain size, was markedly accelerated. It was no longer possible to give a consumer of alloy steels a satisfactory statement regarding the effect of an alloying element in steel without knowing the influence of that element on the transformation of austenite according to the time-rate

\*President, Climax Molybdenum Co. of Michigan, Detroit. This is the second of three articles based on the 13th annual Woodside Lecture presented to the Detroit Chapter.

basis depicted in S-curves. The requirement of this type of investigation resulted in a significant shift in the kind of projects in which we engaged.

Although we did not entirely abandon the study of specific applications of alloy steels and irons, we enlarged our staff and devoted a substantial percentage of our program to a study of some fundamental effects of molybdenum. This was necessary since it soon was evident that it was not enough to subscribe to the new philosophy that the products of austenite decomposition depend upon the temperature of transformation. If one sought to understand the effect of a particular alloying element, it was necessary to measure the delay in the start of transformation at various temperatures which specific amounts of that element could effect when present alone and in combination with other elements. While such measurement was tedious in the temperature range where transformation is slow, it was extremely difficult and required unique apparatus for the temperature range where transformation is rapid. At our laboratory, we went off the deep end and by 1940 had completed several series of S-curves covering the molybdenum-containing S.A.E. steels, carbon-molybdenum steels containing up to 1.2% C and 0.80% Mo, two manganese-molybdenum steels and a high speed steel containing 6% tungsten and 6% molybdenum. We also began to accumulate data on hardenability, as measured by the Jominy end-quench test, to replace the empirical depth-hardness data from the earlier years' effort.

These transformation studies and the data from end-quench hardenability tests disclosed that on the basis of hardenability alone, the role of the principal alloying elements in steel was indeed a highly competitive one. Still further clarification came from Grossmann's studies and it developed that hardenability was better with combinations of alloying elements than with larger amounts of single elements. This concept has not been successfully challenged in the past 15 years.

Throughout this program, Mr. Woodside was on the go to consult with and to arrange consultations for us with such representatives of the metallurgical profession as Zay Jeffries, Edgar Bain, Earle Smith, Clyde Williams, A. E. White, Jim Thorpe, Herb French, Johnnie Mitchell, Ed Davenport, Bob Archer, Al Boegehold, Walter Jominy, Harry Knowlton and Bob Mehl. He took considerable pride in the fact that his establishment had kept pace with the rapid change in alloy steel philosophy.

On the broader basis, no doubt as a result of his planning, this effort fitted in with the extensive programs being completed by the other alloy producers and by the alloy steel industry at large. It was not until the necessity of alloy conservation was upon us that the full significance of the industry-wide program was clarified for everyone. Clarification of the role of alloys in the hardenability of steel proved to be a real help in our job of preparing for war.

While the completion of the program on the hardenability of alloy steels provided a sound foundation for a study of this important contribution of the various alloying elements in steel, it did not answer all the questions of steel consumers. As a matter of fact, clarification of the subject of hardenability served to emphasize the importance of the subsidiary effects which long experience and testing had suggested as being unique contributions of the various alloying elements. Just as one does not challenge the capacity of chromium to impart resistance to corrosion and oxidation, just as one does not doubt the toughness at low temperatures of nickel-bearing ferrite, no one questioned the capacity of molybdenum to improve the creep resistance of steel. It worried us, however, that we had no clear-cut explanation for this effect of molybdenum and it seemed quite appropriate to explore the subject. The theory prevailed that the increase in creep strength imparted by molybdenum was derived from a critical dispersion or shower of a molybdenum-containing carbide phase. There was, as a matter of fact, a considerable amount of circumstantial evidence in support of this theory.

#### Effect on Creep Strength

In the course of our study of the austenite transformation process, we had determined that the first carbide precipitating from the austenite at elevated temperatures invariably contained a relatively high percentage of molybdenum. At first it appeared that this would add support to the widely accepted hypothesis of the carbide shower, but unfortunately we conducted too many experiments. In this instance, we included in our confirmatory program a series of vacuum-melted carbon-free iron-molybdenum alloys. When the results showed that these carbon-free materials exhibited a slightly higher creep strength than the carbon-containing materials of equal molybdenum content, there was no alternative to the conclusion that the role of molybdenum in increasing the creep strength of steel

was through its effect on the solid solution phase rather than the carbide phase. There remained only the elevation of the lowest recrystallization temperature of ferrite (which had been established a few years earlier) as an explanation of this unique contribution of molybdenum. This explanation is inadequate since other alloying elements, also having an appreciable capacity to increase the lowest temperature of recrystallization of ferrite, do not correspondingly augment resistance to creep. It has always been a source of embarrassment to us that however long we ponder this subject we do not seem to measure up to the complexities of this problem.

Still another important aspect of the behavior of alloys has to do with their effects on the tempering of fully quenched steel. Having established that the hardness and structure obtained on the transformation of austenite depend upon the temperature of transformation rather than on the austenite composition, we obviously desired confirmation of the fact that the softening of martensite was dependent on the composition. Statistical data from the hundreds of available physical property charts showed that fully hardened steels of different compositions required significantly different tempering temperatures to arrive at the same hardness. Nevertheless, it appeared to be desirable to review quantitatively as precisely as possible the effect of composition of martensite on tempering. At our laboratory, we undertook an investigation on the fully hardened molybdenum-containing standard steels.

#### Research on Temper Brittleness

Temper brittleness is defined as the loss of room-temperature notched-bar toughness as a result of tempering. It occurs in some steels when they are exposed to temperatures in the range from 850 to 1100° F. Temper brittleness is now known to be a time-rate process and for steels which are susceptible to it, a sojourn of the steel in the temperature range 850 to 1100° F. can permit the development of most undesirable characteristics. Our projects, and those of others, on this subject developed that there is either a cause and effect relationship or a remarkable coincidence between temper brittleness and critical transition temperature. Critical transition temperature is the temperature at which on impact loading the mode of failure changes from ductile to brittle fracture.

Our tests further confirmed that while some alloying elements contributed to temper brittleness, molybdenum reliably lowered the transition

temperature. Research sponsored by the molybdenum industry developed that phosphorus was a contributor of susceptibility to embrittlement of this type and that molybdenum, in the amounts commonly employed in the standard steels, effectively neutralizes this adverse effect of phosphorus. The results of this project are of far-reaching and practical significance wherever the heat treatment of alloy steel is undertaken.

Our studies of Fe-C-Mo alloys confirmed that low-carbon steels containing molybdenum in amounts in excess of about 3% do not transform to the face-centered lattice when heated. We carried the investigation of such alloys to molybdenum contents as high as 25%. Others have found in this work a clue to the development of certain hot die steels but the bulk of our data in this project are still conceded to be of greater academic than practical value since we have not yet learned how to achieve in commercial section sizes the structures and properties which have been attained in the research specimens.

#### Machinability

We took a long and cautious look at the very practical and complex subject of the machinability of alloy steels. We learned how to recommend treatments which lead to improved machinability. We did not find fundamental evidence that machinability could be insured by any additional agent without sacrifice in some other characteristic. We accounted for the commercial reports of improved machinability of molybdenum-containing steels on the basis of the tendency of such steels to develop a structure where the ferrite and pearlite are uniformly dispersed. In such a structure, relatively good machinability is obtained at somewhat higher carbon and hardness levels than one might normally expect in compositions of comparable hardenability.

In this period of confirmation and conformance, it was established that the advantages of molybdenum in alloy steel were:

1. It is an effective contributor to hardenability of steel.
2. It does not induce susceptibility to temper brittleness and within limits neutralizes the susceptibility to embrittlement induced by other elements.
3. It contributes to elevated-temperature strength and hardness. It is the most effective single addition to attain creep resistance.
4. It increases red hardness.
5. It permits the employment of high harden-

ability compositions with a minimum sacrifice in machinability.

6. Except when present in amounts exceeding about 4%, it does not require significant modification of the established practices for producing, heat treating and fabricating the steels containing it. Scrap can be recycled without significant loss of molybdenum.

It is necessary to emphasize that this account of molybdenum research at our laboratory should not be construed to imply that all development in molybdenum was the sole product of a single laboratory. On the contrary, we drew heavily on the research effort of the whole industry and the development work essential at the level of practice, supplied by industry at large, far surpasses the combined research effort. Nevertheless, we are proud to have been a part of that program.

#### Role of Molybdenum in Cast Iron

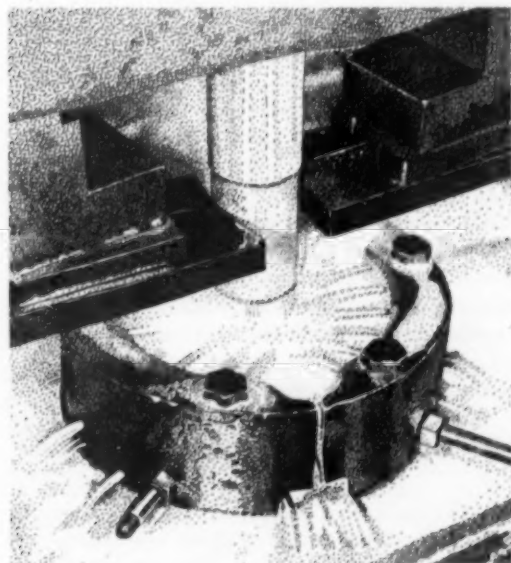
No account of this period in molybdenum research would be adequate if it did not review the progress in the development of alloy cast iron. Even the earliest attempts to alloy cast iron with molybdenum gave considerable promise. Accumulated data during the formative years confirmed that herein lay an important application of molybdenum.

The fundamental transformation processes in cast iron are of course the same as the fundamental transformation processes in steel. In cast iron, however, the attainment of the ultimate

properties is further complicated by the presence of graphite. Depending upon the controlling factors in solidification of cast iron, graphite manifests itself in various states of dispersion. Foundrymen were not long in cataloging several typical states of dispersion and recognizing dependence on the nature of the furnace charge and the melting and pouring temperatures. At a very early date in this development, Victor Crosby told us how late additions of ferrosilicon would effectively modify the graphite dispersion. Our laboratory experiments confirmed this and we believe this to have been a most important step toward super cast irons. Other forms of inoculating materials and processes appeared from the work of others in the foundry industry.

It is now relatively easy to see that without this important first step a coherent relationship between the alloy content and the properties of cast iron would have been virtually impossible. Actually, however, with the graphite type under control, the study of the role of alloys in cast iron became reasonably straightforward. We proceeded in such an investigation fortified with the conviction that the matrix of the iron could be made self-heat-treatable during cooling through relatively larger additions of molybdenum than those normally used in steel. This was possible since earlier work showed that molybdenum neither stabilized nor promoted graphitization of the carbide phase. We also investigated the heat treatment of cast iron with special attention to the reactions occurring during the heating of the iron. We observed the complete graphitization of the carbide phase and the gradual re-solution of the graphite to generate the austenite to be transformed on subsequent cooling.

These studies, coupled with the studies on inoculation, brought us to the point where we could make contributions to the development of the super cast irons in which all of the foundry industry was participating. These cast irons not only displayed superior strength in even relatively heavy sections but also possessed enough resistance to impact so that they could be used in many applications formerly restricted to wrought steels, cast steels or malleable iron. In many respects, the developments in alloy cast iron during this period were more dramatic than the developments in steel, since the time interval between a laboratory heat demonstrating the potential of a composition and an established use was often not over six months.



# Design of High-Temperature Alloys— Cermets and Oxide Dispersions

By Nicholas J. Grant\*

The best alloys now known are based on cobalt and on nickel, the first age hardened by carbide dispersion and the second by  $Ni_3(Al, Ti)$  compound. Pure metals, refractory and ductile, may be strengthened by oxide dispersions or used as binders for hard, brittle particles. (Q general, SG-h, C-n, Co, Ni)

**I**N LAST MONTH'S *Metal Progress* one phase of the problem of "designing" a material for high-temperature service was rather broadly assessed. Certain inherent physical and mechanical properties were listed for pure metals available, and the influence of fabrication history on expected service life was cited. In this article a similar presentation will be made for alloys and dispersed nonmetallic compounds.

Strength through alloying is an extremely complex, poorly understood subject. Very little significant work has been done in the more complex commercial alloys. In part the complications are due to the broadness of the subject itself; "alloying" includes one or more of several

matters such as matrix strengthening by a solid solution, strengthening by one or more separate phases, and a variation of the latter by aging and precipitation. A few principles are derived from our knowledge of single-phase, simple binary alloys systems, but alloying still depends mainly on trial and error.

It is not my purpose to evaluate the state of the alloying art, but merely to determine to what extent alloy development has utilized the known principles.

**Solid Solution Alloying**—For high-strength service above 1250° F. there are relatively few commercially pure metals or solid solution alloys in use. As pointed out in the article last month about pure metals, this is because of their limited creep resistance, and a high melting point is required to assure a relatively high recrystallization temperature. This is also true for solid solution alloys. Pure platinum and a number of its solid solution alloys find service where oxidation resistance is the most important property. The best known single-phase (or essentially single-phase) alloys in use commercially are the nickel-chromium (Nichrome type), nickel-chromium-iron (Inconel type), and low-carbon stainless steels (austenitic and ferritic). Without exception they are weak above about 1250° F., but all enjoy good oxidation resistance, thermal shock resistance and high ductility.

Almost all of these alloys are quite simple in composition. If one considers the work done

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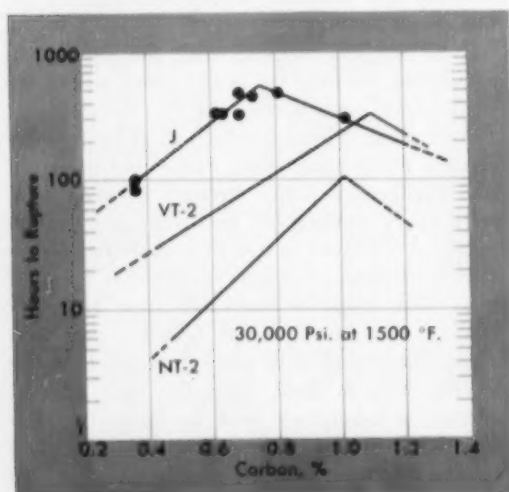


Fig. 1—Contribution of Carbon Content to the High-Temperature Strength of Three Heat-Resistant Cobalt Alloys at 1500° F. Cast test pieces.

by Lindsay and his associates on the creep resistance of iron containing one atomic percent additions of various elements, and of Sherby, Anderson and Dorn on alpha aluminum alloys and the benefits to be derived from multi-element alloying, one concludes that there is very much that needs to be done to improve the strength of most of our current solid solution alloys.

**Multiphase Alloying**—Most commercial alloys retain high-temperature strength and creep resistance primarily on the distribution of a stable second phase or of several hard phases. Some precipitation may take place either before or during service, but the benefits are lost early in life or the precipitation is of little account anyway. We can consider the alloys listed in Table I to be representative.

While the carbides change in composition during test or service at temperatures higher than about 1300° F., the effects are not profound. In most of the alloys of Table I the amount of  $M_6C$  type of carbides increases with time. Strength depends rather on a highly alloyed matrix of face-centered cubic crystallinity and an extensive dispersion of carbides, thus increasing creep resistance.

The importance of carbon as the major hardening agent in the cobalt-base alloy systems is shown in Fig. 1 and 2.\* Figure 1 shows the increase in rupture life for a number of cobalt alloys listed in Tables I and II with increasing carbon content, and Fig. 2 shows the correspond-

\*In Fig. 1 and 2 Alloys J, VT-2, N-2 and NT-2 are alloy systems. The designation 110 VT-2 in Table I indicates that the alloy contains 1.10% C; Alloy 73 J in Table II contains 0.73% C; 100 NT-2 contains 1.00% C. The N-2 alloys are the same as the NT-2 system but without the 2% Ta.

Table I—Representative Complex High-Strength Alloys  
(Limited Age Hardening Type)

ALLOY	Ni	Co	Cr	Mo	W	OTHERS	C	Fe
S-590	20	20	20	4	4	4 Cb	0.5	Bal.
S-816	20	Bal.	20	4	4	4 Cb	0.5	3
Hastelloy B	64	—	—	29	—	—	0.05	5
Hastelloy C	54	1.2	16.5	17	4.5	—	0.09	5
422-19	15	Bal.	25	6	—	—	0.4	—
HS-21	2	Bal.	27	6	—	—	0.4	—
110VT-2	20	Bal.	23	6	—	2 Ta	1.1	—

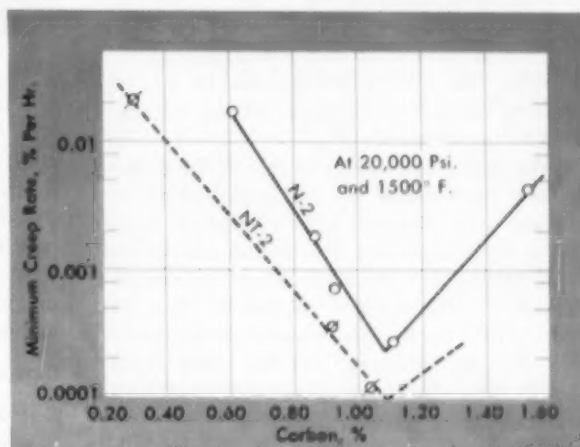


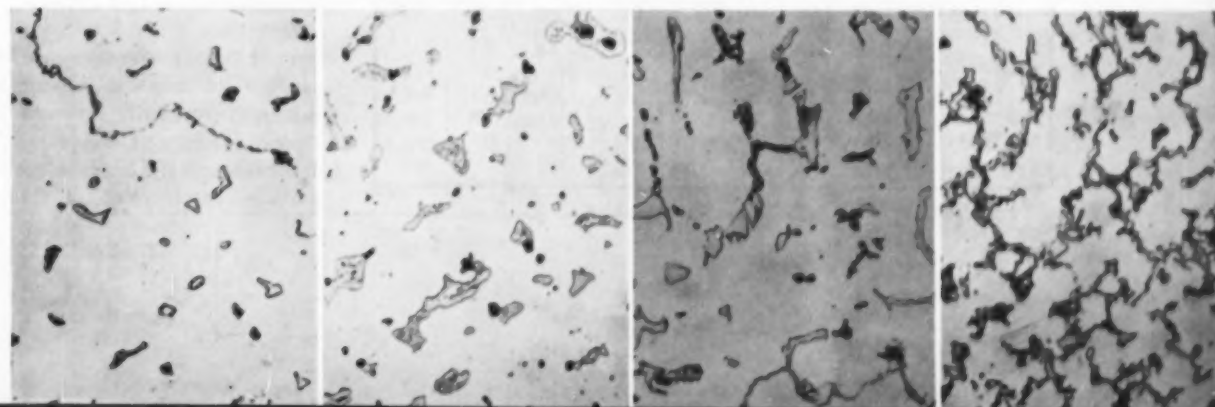
Fig. 2—Relation of Carbon Content to Minimum Creep Rate of Two Heat Resistant Cobalt Alloys at 1500° F. Cast test pieces.

ing improvement in creep resistance. Correspondingly, Fig. 3 shows the increase in dendritic carbide and progressively greater continuity of the carbide phase as the carbon goes up. However, when the carbide phase becomes massive or continuous, there is a decrease in strength, a further decrease in ductility and in creep resistance. (All these results are for the alloys in the cast condition, although similar effects prevail for wrought alloys.)

In a number of other cobalt-base alloy systems carbide is effective for precipitation hardening

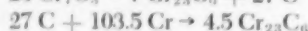
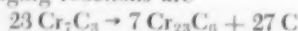
Fig. 3—Carbide Dendritic Network Increases in Cast J Alloy With Increasing Carbon Con-

tent. Micros at 200 diameters. Carbon analyses: 0.36, 0.70, 0.81 and 1.02%, left to right.



and strengthening, and increases significantly the high-temperature properties over those attained by straightforward increases in the massive carbide phase. The alloys' compositions are balanced to take advantage of this change in the type and distribution of carbide.

Figure 4 shows the increase in rupture time for 73 J as a function of several different aging treatments. It has been established in previous work in the author's laboratory that the most probable aging reactions are



On aging, the  $\text{Cr}_7\text{C}_3$  decomposes to  $\text{Cr}_{23}\text{C}_6$ , liberating carbon which then diffuses into the matrix to form more  $\text{Cr}_{23}\text{C}_6$ .

In the nickel-base alloys of the Nimonic 80 A and 90 types, Inconel "X", and others which are hardened with titanium plus aluminum, aging is even more important than in the cobalt-base alloys; otherwise the nickel alloys are single-phase alloys after solution treatment—they depend entirely on the precipitation of an excess phase for strengthening. On the other hand, most of the cobalt-base alloys are multiphase alloys even after solution treatment.

Nickel-chromium (30-20) and nickel-chromium-iron (79-15-6) alloys can be strengthened with additions of titanium alone (when the precipitate is  $\text{Ni}_3\text{Ti}$ ) or aluminum alone (when the precipitate is  $\text{Ni}_3\text{Al}$ ) or by additions of both (whereupon the precipitate is based on  $\text{Ni}_3\text{Al}$ ).  $\text{Ni}_3\text{Al}$  has a large tolerance for the substitution of titanium for aluminum—up to three atoms of titanium out of every five of aluminum to produce a formula  $\text{Ni}_3(\text{Al}, \text{Ti})$  of larger lattice structure which more effectively hardens the matrix than the  $\text{Ni}_3\text{Al}$ .

Unfortunately, aside from these two common aging systems—namely, carbides in cobalt-base alloys, and  $\text{Ni}_3(\text{Al}, \text{Ti})$  in the nickel-chromium class of alloys—there is very little known about other aging systems which might be effectively used in high-temperature alloys. The aging which

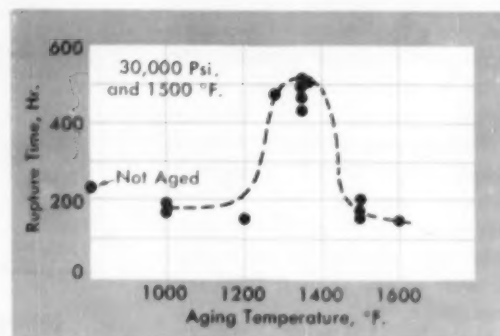


Fig. 4—Effect of Aging Temperature on Rupture Life of Cast J Alloy at 30,000 Psi. and 1500° F.

takes place in the nickel-base alloys has been studied in an outstanding way by Taylor and Floyd; their careful work on the phase diagrams published in *Journal of the Institute of Metals* in 1952 has given metallurgists a much greater understanding of the age hardening process, and has enabled them to utilize it more effectively.

#### Cermets

A distinct departure from the cast and forged grades of heat resistant alloys are the cermets—ceramic-metal combinations. While silicide, carbide, and boride cermets have all shown very high strengths at 1800° F. and above, their limitations, as yet not overcome, of poor ductility at temperatures below 1600° F. and limited thermal and mechanical shock resistance at all temperatures have held back their application where such factors are critical. These cermets have shown greater strength than the cobalt-base or the nickel-base alloys at 1800° F. In fact there is evidence of a useful amount of ductility at 1800° F. in the titanium carbide cermets made by the infiltration process, or in cermets, conventionally prepared, in which the metal phase is greater than 50% by volume.

Materials of this type will undoubtedly be improved through additional research and development. A sharp decrease in the size of the titanium carbide particles (to something nearer 1 micron rather than 5 to 10 microns) should permit a greater proportion of metallic binder, and also avoid the propagation of fracture at very rapid rates through the hard, brittle carbide. Interruption of the

Table II—Representative Alloys Which Effectively Precipitation Harden

ALLOY	Ni	Co	Cr	Mo	W	Mn	OTHERS	C	Fe
73 J	6	60	23	6	—	1	2 Ta	0.73	—
X-40	10	55	25	—	7	0.5	—	0.5	—
N-155	20	20	20	3	2	1	1 Cb	0.15	Bal.*
100 NT-2	30	20	20	3	2	1	2 Ta	1.0	Bal.
Modified Hs-21	2	Bal.	25	6	—	1 to 4	—	0.3	—

\*Also contains 0.12% nitrogen.

Table III—Stress for 100-Hr. and 1000-Hr. Rupture Life of Wrought Aluminum Powder Products

ALLOY*	TEMPERATURE	STRESS FOR RUPTURE	
		100 Hr.	1000 Hr.
SAP	400° F.	24,500 psi.	22,000 psi.
	600	15,500	14,000
	900	8,500	8,000
M-276	400	22,500	20,500
	600	14,000	13,000
	900	7,000	6,000
M-257	400	17,000	16,000
	600	12,000	11,000
	900	7,000	6,300
M-293	400	14,000	13,000
	600	9,500	8,500
	900	2,700	2,000
M-255	400	9,000	8,000
	600	4,200	3,200
XF 18 S-T61†	600	5,500	4,000‡

\*The average oxide content of these products is SAP, 12%; M-276, 16%; M-257, 7%; M-293, 2%; M-255, 0.7%.

†One of best conventional, age hardenable, wrought, high-temperature alloys.

‡Extrapolated.

continuity of the carbide phase and the more definite separation of each carbide particle from its neighbors should be a developmental goal. Finally, efforts to decrease the solubility of the carbide in the matrix appear to be a worth-while project. Possibly an adjustment in the carbide composition, or even a new type of hard particle, may be the ultimate answer.

**Strengthening by Dispersed Hard Particles**—Fortunately there is on the horizon a new and different method for forming parts with both high-temperature strength and high-temperature stability. This promise of a new system of alloys is based on the improvements shown by the product known as SAP ("Sintered Aluminum Powder") when compared to conventional cast and wrought aluminum alloys intended for "high-temperature" service. This is made of ultra-

fine unalloyed aluminum flakes or powdered particles which have a thin skin of aluminum oxide. After pressing and sintering, the compact is hot worked, preferably by extrusion, to yield a continuous aluminum phase in which are embedded flakes of exceedingly thin  $Al_2O_3$  spaced possibly 0.1 to 0.2 micron apart. Coarser aluminum flake or powder yields wider spacing among the oxide particles, lower oxide content for a given thickness of oxidized skin, and lower strength but higher ductility.

Table III summarizes the stress-for-rupture values in 100 and 1000 hr. at 400, 600, and 900° F. for SAP and four experimental Alcoa products of increasing  $Al_2O_3$  content, and compares these results with those of the best known wrought, age hardenable, high-temperature aluminum alloy, XF 18 S-T 61, containing approximately 4% Cu, 2% Ni and 0.6% Mg.

It will be noted that M-257 and SAP are as strong at 900° F. as one of the best of the wrought aluminum alloys is at 600° F. They therefore have an advantage of over 300° F. for equivalent creep-rupture properties. However, of even greater importance is their stability. Table IV shows the room-temperature tensile strength of the SAP product after 100 hr. of heating at progressively higher temperatures up to 900° F. Conventional alloys would have over-aged above 500° F. and become quite weak. Recent efforts to recrystallize the 12 to 15%  $Al_2O_3$  products after maximum cold work have not been successful at temperatures as high as 1150° F.

It is important to point out that the work with the oxidized aluminum bodies does not culminate simply in an ultra high-strength aluminum product. Instead, a whole series of alloys have become available which combine an important range of strength and ductility values to meet a variety of requirements.

That similar principles can also be applied to the refractory metals is shown in Table V. Molybdenum was improved by the addition of oxides such as  $ZrO_2$  in powder form, and a

Table IV—Properties at Temperature and at 70° F. After 100 Hr. at Temperature

ALLOY	EXPOSURE TEMP.	TENSILE STRENGTH		0.2% YIELD		ELONGATION	
		At Temp.	At 70° F.	At Temp.	At 70° F.	At Temp.	At 70° F.
SAP	200° F.	41,000	50,000	35,000	34,200	10%	10%
	400	32,000	50,000	30,400	34,000	8	9
	600	24,000	49,500	22,000	34,000	5	8
	900	15,000	49,000	14,000	33,000	2	7
M-257	600	16,900	—	15,000	—	13	—
XF 18 S-T 61	600	11,000	—	8,000	—	49	—

Table V—Oxide Mixtures in Molybdenum and Nickel

PRODUCTS	TEMP.	STRESS	RUPTURE LIFE	ELONG.
Pure Mo	1800° F.	25,000 psi.	80.0 Hr.	—
Mo + 1% ZrO <sub>2</sub> *	1800	25,000	170.0	—
Pure Ni	1500	5,000	0.2	90%
Ni + 10% Al <sub>2</sub> O <sub>3</sub>	1500	5,000	145.0	5

\*Data from Battelle Memorial Institute.

nickel-powder product to which fine Al<sub>2</sub>O<sub>3</sub> was added was likewise improved. Both powder products were wrought by hot working.

The improvement in strength of molybdenum by the small oxide addition was equivalent to that achieved by one of the best alloys of arc cast and forged molybdenum shown in Table II of the article last month. In the nickel system, there was a 500-fold increase in rupture life. In both systems, the optimum oxide content and particle dispersion have not yet been achieved and there is much to be learned about the design of these alloys for specific applications.

#### Design of an Alloy

Because an alloy may be used for any one of many applications and the nature of the stress pattern in each may vary significantly from any other, the temperature may be steady or variable, or the atmosphere may be corrosive or essentially protective, it would be impossible to specify rigorously the design of an alloy. Furthermore, specific reference to the nature of the application, or to such features as notch sensitivity, multi-axial stress systems or radiation damage, cannot be made without undue complication. However, examination of the nature of the alloy systems currently known to us or theoretically attainable does point out a number of important factors common to most of them. It should be noted that these conclusions apply both to the commercially pure refractory metals, to their alloys and to cermets.

1. Oxidation resistance and, more generally, corrosion resistance are essential. Primarily we depend on chromium (from 15 to about 35%). Such resistance as it gives may be improved by additions of aluminum or silicon and may be worsened by the presence of vanadium (greater than about 1%) or molybdenum (greater than about 3%, except in high-nickel alloys).

2. Where high strength is not of great importance, simple, single-phase alloys can be used and can generally be relied upon for good thermal shock resistance (resistance to cracking,

though not to warping) and good corrosion resistance.

3. When thermal stresses or applied stresses are high, reliance is placed on more complex alloys. Multiphase alloys, either age hardenable or not, have found extensive and successful use. The age hardenable grades

are somewhat less reliable if important temperature variations are to be anticipated above the temperature of optimum aging.

4. The higher the recrystallization temperature the better the alloy, since the higher will be the temperature prior to the incidence of intercrystalline cracking, and the higher the useful ductility of the alloy. The higher the recrystallization temperature, the higher the temperature at which cold worked or warm worked alloys can be used without running the danger of rapid reduction in strength.

5. Castings offer greater promise of yielding high strength at high temperatures than do forgings of the same composition. Since forgeability may be disregarded, castings may be selected from a wider variety of compositions.

6. To achieve optimum stability, hardening by finely dispersed, insoluble hard particles may prove to be the most effective scheme. These hard particles may be oxides, carbides, silicides, borides, nitrides — but must not have a significant solubility in the ductile matrix metal or matrix phase at any temperature to be encountered either in fabrication or in use.

#### Summation

Close study of the alloys and alloy systems currently available for high-temperature service shows that the most reliance is now placed on two basic aging systems, namely, carbides in cobalt alloy systems, and Ni<sub>3</sub>(Al,Ti) in the nickel-base alloy systems. There is a large void in our knowledge of the fundamentals of alloying which is especially noticeable when one considers systems involving more than two elements. Knowledge of the interplay of alloying elements, and of partition coefficients, is almost completely lacking. This results in the fact that a number of new metals with high melting points deserve much more study. The two most important ones are chromium and columbium. Since the first-named is now available in quantity and in a high degree of purity, one might expect that research will be especially fruitful in that direction. ☉



(Aluminum Company of America photo.)

**At one stroke** this press can forge pieces 10' wide or 24' long. It can change a 2,000-pound aluminum slab into a complicated aircraft component... saving material as well as machining and assembly time. Cast and forged nickel alloy steels provide the strength and

toughness needed in columns, cylinders, die-block holders and dies of this giant machine. Among the first of the facilities in the U. S. Air Force Heavy Press Program, this unit is a notable engineering achievement of United Engineering & Foundry Co., Pittsburgh, Pa.

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Nickel alloy steel provides the level of strength and notch toughness required. These massive columns are each 61' high and 34" in diameter. Whenever a component's size restricts methods of heat-treating, or permits forging only limited portions at a time, improved strength and elastic properties depend particularly upon correct alloy content.

Nickel alloyed steels are used for still other parts that encounter high stresses and loads.

Dies and die holders gain needed stamina from additions of nickel. Among the largest steel castings ever used in press construction, the top and bottom die holders of this press are nickel-chromium-molybdenum steel approximating the 4340 composition. Each measures 26' by 12' by 25" and weighs 350,000 pounds.

In many a metal, you can improve specific properties by use of nickel alone or in combination with other alloy elements. When you seek the solution to a metal problem, let us give you the benefit of our wide practical experience.

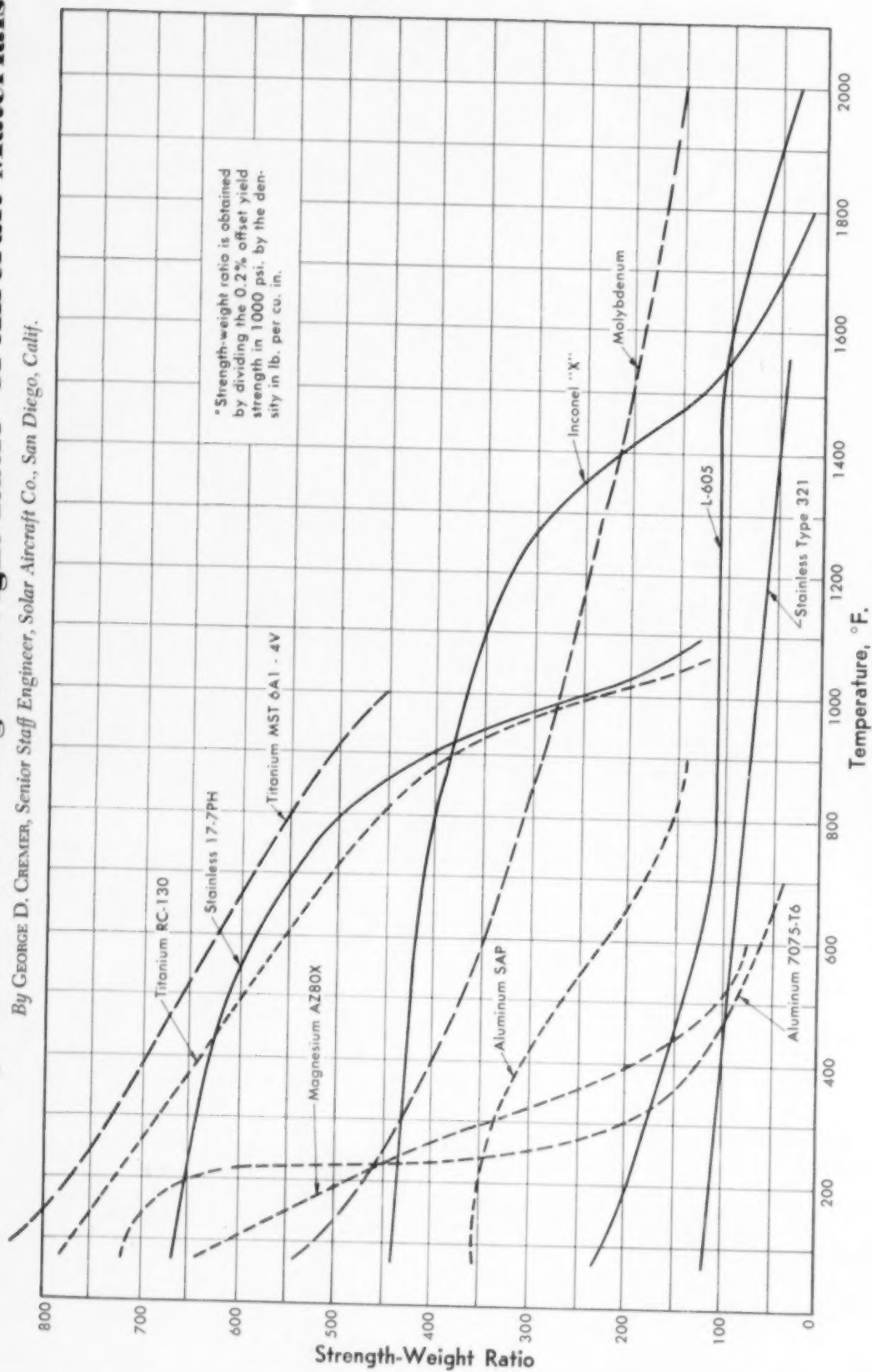
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# Effect of Temperature on Strength-Weight Ratio\* of Aircraft Materials

By GEORGE D. CREMER, Senior Staff Engineer, Solar Aircraft Co., San Diego, Calif.

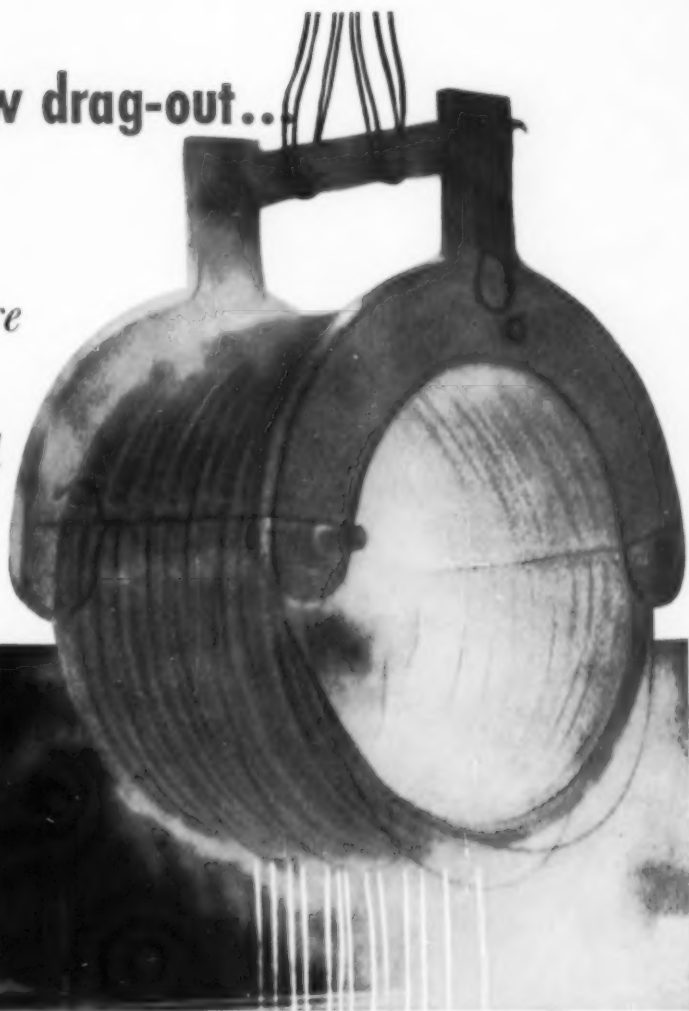


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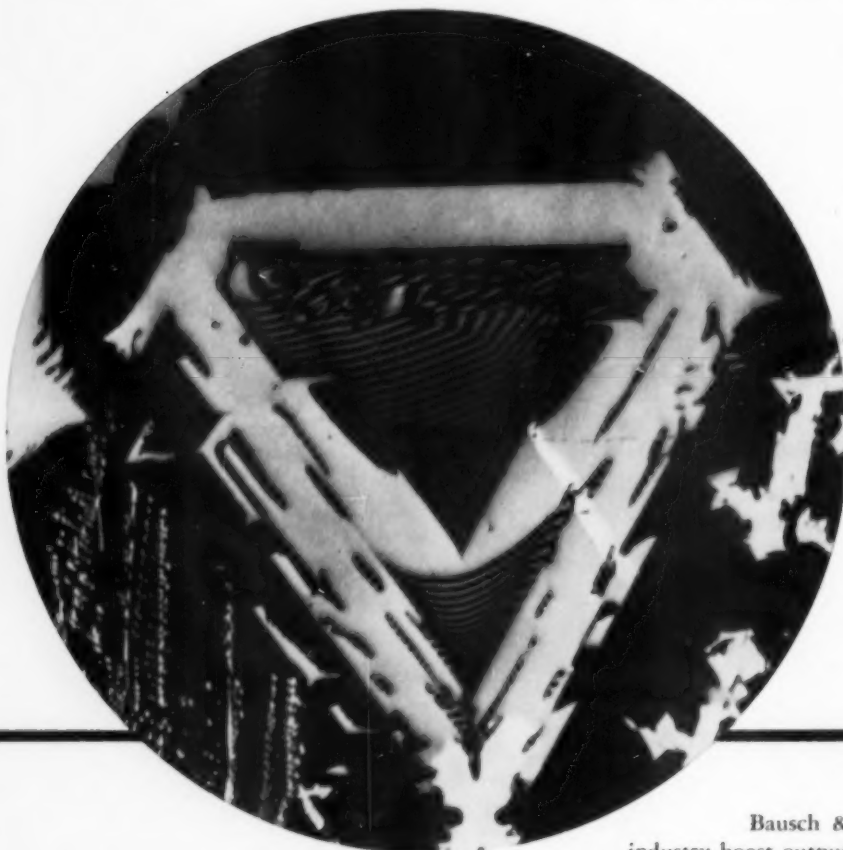
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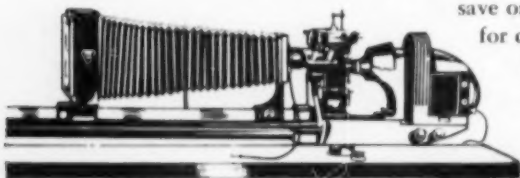


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# Steels Degassed During Pouring of Large Forging Ingots

By ARTHUR TIX\*

When well-made steel is teemed into a mold in a vacuum chamber (5 mm. Hg) half of the hydrogen is sucked out and the steel is free of flakes even if sections as large as 30-in. rounds are air cooled from the forging heat. (D8, D9, ST)

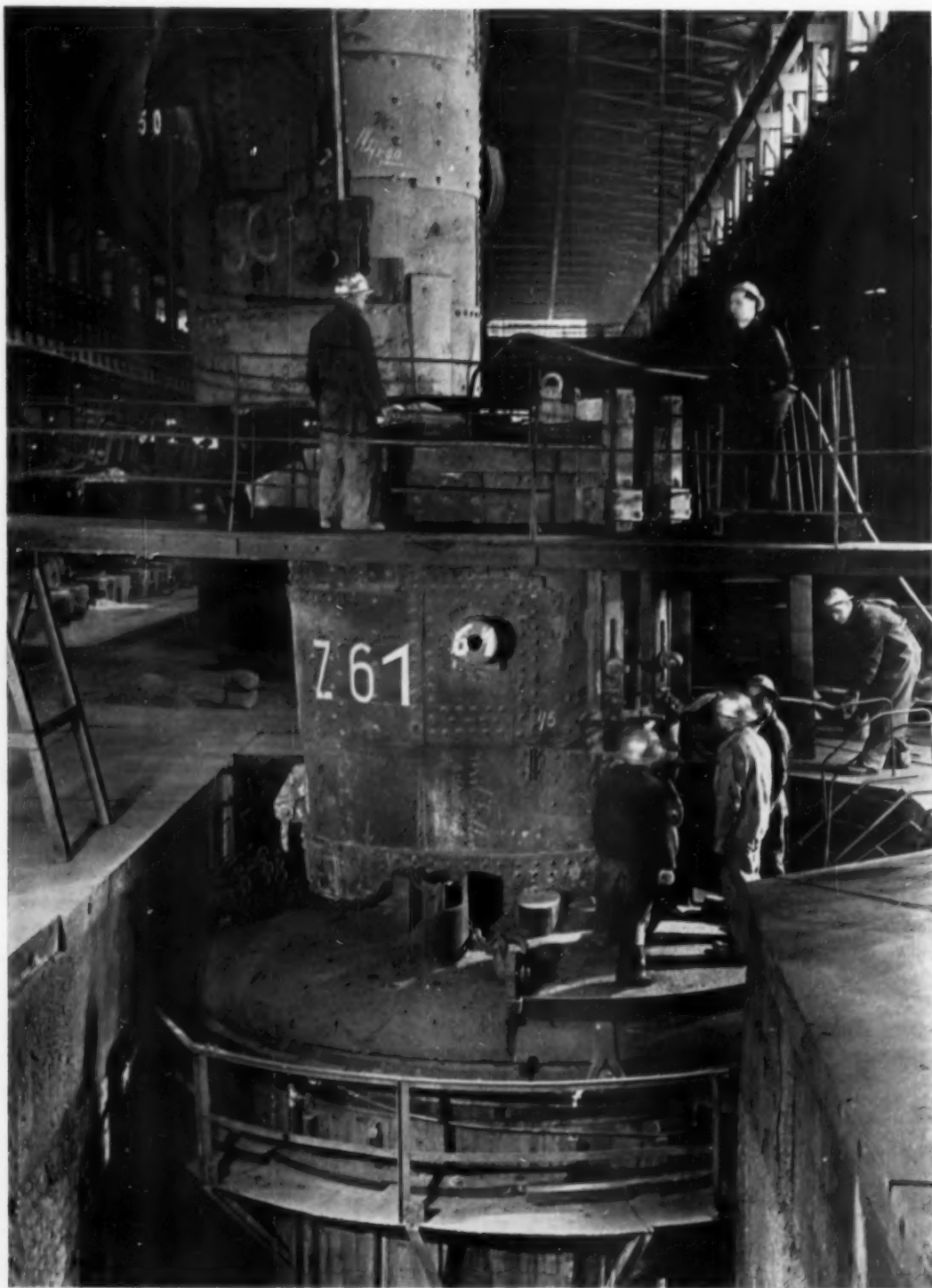
IT HAS been known for a long time that there is an intimate connection between gas content in steel — even though in amounts much less than other impurities like sulphur and phosphorus — and the quality of mill products and the machine parts or ordnance items made therefrom. Suspicious gases are oxygen, hydrogen and nitrogen. Most of the gas is acquired in the steel furnace from the air or moisture in the charge; some of it forms compounds or nonmetallic inclusions; other portions remain atomically dispersed. Another source of gas is the surrounding air or prepared atmosphere during heat treatment, after which the gases or their compounds tend to remain concentrated close to the surface. In other operations, such as acid pickling, hydrogen is absorbed by the steel; its rate of diffusivity in solid metal is high, and it has a well-known embrittling effect. The reasons are obscure; they do not need to be discussed here.

These matters are of great concern to the maker of steel ingots for heavy forgings — gun tubes, propeller shafts, armature spindles — and for heavy rolled products like rails. In large, important forgings, as pointed out in the article in *Metal Progress* for February (p. 49), the working loads tend to build up into bi-axial and even tri-axial stress systems which hinder the normal plastic yielding so necessary to avoid brittle failure. Also the design loads in their worst combination can be very high, so that stress-raisers

like tiny cracks (flakes), hard spots of segregates, or inclusion clusters must be avoided at all costs, and special precautions have accordingly been taken in the melting, refining, casting, and heat treatment of large blocks of steel.

Many recent publications have confirmed work started by W. Rohn in Germany on a small scale in the late 1920's. He melted and cast steels and special alloys in induction furnaces up to 5 tons capacity in a vacuum of about 5 mm. of mercury. Special steels are now so made commercially in America and elsewhere in 1-ton ingots, and exhibit superior properties to the corresponding materials melted and cast under the atmosphere. In view of the advantages which undoubtedly would accrue to larger ingots and products made therefrom, it seemed to us at Bochumer Verein more practical to use the best conventional furnace practices (dispensing with melting in vacuum) and simply *pour* in vacuum into the ladle or mold. Since 1952 our production of vacuum steel, made in the way to be described, has amounted to some 25,000 tons of forging

\*Works manager, Bochumer Verein, Bochum, Germany. The article is a briefed version of a translation prepared under the author's direction of Report No. 587 of the Steel Works Committee of Verein Deutscher Eisenhüttenleute, as published in *Stahl und Eisen*, Jan. 26, 1956, p. 61, and reproduced here by the kind permission of Dr. Kurt Thomas, general secretary of the Verein Deutscher Eisenhüttenleute.



*Fig. 1 — Equipment for Casting Ingots Weighing Between 40 and 150 tons. The vacuum container is in a pit some 30 ft. deep. The intermediate ladle receives metal from a succession of tapping ladles and maintains a steady flow into the ingot mold at optimum rate*

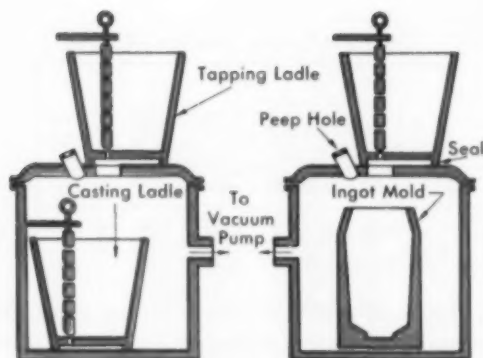


Fig. 2 - Schematic Views of Teeming Degassing (at Left) Where the Degassed Metal Is Later Cast in Air, and Ingot Degassing (at Right) Where Metal Direct From the Furnaces Is Degassed as It Is Teemed Into the Mold

ingots up to 150 tons. In addition, some 900 tons of high-grade steel castings were poured after similar vacuum treatment of the molten metal.

There were three schemes open to us:

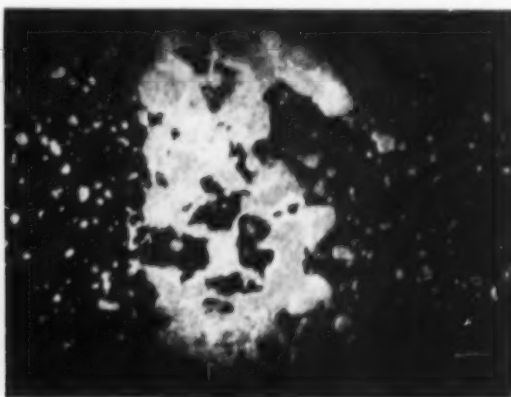
1. Ladle degassing, in which a ladle of hot steel from the furnace is put into a vacuum chamber and pumped.
2. Teeming degassing, in which a ladle of hot steel from the furnace is poured (through an appropriate trap) into a second ladle in a vacuum chamber, continually pumping the while, and is cast from this second ladle.
3. Ingot degassing, which is similar to the last mentioned, except that an ingot mold is in the vacuum chamber.

Ladle degassing has only limited application.

Fig. 3 - Left Is Stream of Metal in Air 5 Ft. Below Nozzle; It Is About 2 1/2 In. Diameter. Right is stream of steel at same temperature



and from same nozzle but falling in vacuum of 5 mm. Hg; the stream is dispersed into a spray at least 10 times the diameter



During pumping the metal boils, but this motion is confined to the upper part of the liquid; the lower layers in the ladle cannot take part in the surface reactions unless the whole melt is stirred.

**Teeming** or stream-droplet degassing is shown in principle at the left of Fig. 2. The empty casting ladle is first degassed in the vacuum chamber, the tap entry being sealed by a sheet of aluminum. This promptly fuses when molten steel strikes it. With a pouring rate of about 10 tons per min., the transfer will drop the temperature 60° F. The ladle is then taken out and its contents teemed into ingot or casting molds.

**Ingot degassing** — the process which we favor at Bochumer Verein in equipment shown in Fig. 1 — is as diagrammed at the right of Fig. 2. There is an ingot mold inside the vacuum chamber. An intermediate ladle, such as is normally used to assemble metal from several furnaces in the casting of heavy ingots, is placed on top the cover. Of course the tapping ladle can also replace this intermediate ladle. If the steel can stand a considerable drop of temperature, both the processes sketched in Fig. 2 can be applied successively to the same melt. Indeed this has occasionally proved to be an advantage. As far as the equipment is concerned, there is no limit to the size of the ingots which can be cast.

#### Advantages of Degassing

Our vacuum equipment was designed on the basis that the steel would evolve its own volume in gas (measured at standard conditions). Suitable drying filters with simple cleaning devices protect the pumping system from dust.

Quite important is the prevention of oxidation

of the stream of molten metal as it falls from the nozzle into the mold. Neither are splashes on the mold wall dangerous, as has been determined during later forging.

As the killed, nondegassed steel enters the vacuum, the stream is split into tiny droplets, and this intensifies the degassing process. The behavior of the metal stream depends on the degree of the vacuum, on the shape of the nozzle and on the gas content of the steel. Therefore the operator, who can view conditions in comfort through proper peep holes, is in a position to vary the casting conditions within quite wide limits. While a spraying stream is undesirable when casting in air, on account of the ensuing oxidation, this factor is an essential feature of vacuum casting. Since droplet dispersion exposes a very large surface of molten metal, as shown in Fig. 3 at right, effective degassing can be accomplished even at relatively high pouring rates.

Experience has shown that when vacuum casting it is inadvisable to coat the mold. This eliminates the well-known danger that the steel may absorb hydrogen from the coating — sometimes the source of half the hydrogen in the steel. Uncoated molds used in vacuum casting of ingots have a longer life than the coated molds used in air casting. It is also evident that the escape of gas is particularly rapid at the mold wall, and this has the same repellent effect on nonmetallic particles as a good coating has. Dross of this kind, however, occurs very rarely in vacuum cast ingots.

Preliminary pumping of ladle or mold is particularly important for the hot top which often contains considerable quantities of water remaining after the ordinary drying with gas burners.

When teeming a heavy forging ingot the casting rate is controlled to accomplish a desirable balance of factors. Slow casting will mean a larger temperature drop from beginning to end of cast; oxide inclusions will not rise so easily and ingot imperfections may result. Too rapid casting may cause excessive boiling of the steel

Table I — Typical Analyses of Steels

STEEL	C	Si	Mn	Al
Ck 35	0.35	0.40	0.65	0.004
Ck 45	0.45	0.30	0.75	0.005
75 Mn 3	0.60	0.35	0.90	0.004
46 MnSi 4	0.45	0.85	1.05	0.004

Phosphorus and sulphur each less than 0.03%.

at the mold walls and cracks in the ingot. In vacuum casting, due to the much lower gas content in the molten steel in the mold, a high casting speed may be maintained; or it may be kept low without risking inclusions formed by oxidation since the oxygen content is greatly reduced by the degassing. It is noteworthy, too, that the degassed steel possesses better fluidity than nondegassed steel.

#### Gas Analyses

As soon as the mold is full, normal atmospheric pressure is restored. Since the vacuum used in our casting process (1 to 10 mm. of Hg) cannot be called a high vacuum, and since the container and mold may give off some gas, the gas which is pumped during casting cannot be regarded as giving an accurate idea of what actually comes out of the metal. Nevertheless, it is indicative. An analysis during the casting of a 25-ton ingot of chromium-molybdenum steel, for example, resulted as follows: 40% CO, 3.8% CO<sub>2</sub>, 23.0% H<sub>2</sub> and 33.2% N<sub>2</sub>. The proportion of CO to CO<sub>2</sub> checks the theoretical conclusion that additional deoxidation occurs at low pressure in steels containing 0.10% carbon or more and low aluminum.

**Hydrogen From Molten Steel**—The liquid steel samples were taken from a ladle in front of the furnace or from an uncoated testing mold poured from the tapping ladle. This represents the metal before degassing. For the vacuum cast ingots the samples were extracted from the hot top through an observation window. Analysis for hydrogen was by the so-called tin-fusion process devised about 15 years ago in the Krupp laboratories.\* This gives values considerably higher than those from other methods. Table I shows the typical analyses of the steels sampled, and Table II gives a hydrogen analyses (cc. at normal conditions per 100 g. of steel) of the

Table II — Hydrogen\* in Liquid Steel

STEEL	IN LADLE	AFTER DEGASSING
Ck 35	6.8, 6.4	3.6, 3.1
75 Mn 3; Cast A	5.5, 6.2	2.8, 3.5, 3.2
Cast B	6.0	3.2, 3.4
Cast C	6.2, 6.4, 6.2	1.7, 2.5

\*In cc. at normal pressure and temperature per 100 g. of steel, multiply by 0.9 for parts per million.

\*See articles by H. Bennek and G. Klotzbach, *Stahl und Eisen*, Vol. 61, 1941, p. 597, 624 and 675, and by H. Wentrup, H. Fücke and O. Reif, *Stahl und Eisen*, Vol. 69, 1949, p. 117.

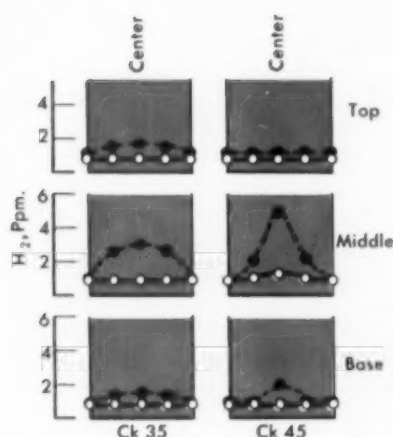


Fig. 4—Hydrogen Analyses Across Round Forgings From 21-Ton Ingots. Dotted lines represent air cast; full lines vacuum cast. Ck 35 was forged to 21-in. round; Ck 45 to 32-in. round

liquid steel before and after degassing. These figures show that half of the hydrogen in the molten steel as it leaves the furnace is extracted before the liquid metal solidifies in the mold. Not much more could be extracted in the vacuums we use (5 to 12 mm. Hg) since the equilibrium solubility at 1600° C. (2900° F.) is 2.0 to 5.0 cc. per 100 g. in that range of pressures, but considerably lower hydrogens have been achieved when pumping to higher vacuums.

**Gas From Ingots**—We have compared the gas analyses of forging ingots from split heats of various engineering alloy steels, part of the metal being cast into molds in the air, following the best practices, and part being cast in vacuum. Average values for four steels are shown in Table III on p. 86.

Of particular interest to users of large forgings is whether hydrogen content may vary widely within the cross section. As a result of its solubility drop during solidification, segregation must be expected. It is difficult to measure this, since hydrogen diffuses so readily, but this possible segregation was investigated in our study of differences in the hydrogen content between air cast and vacuum cast ingots. Care was taken to insure that when cutting the sample it was not heated above 75° F., and that it was analyzed promptly. The vacuum fusion method was used. Figure 4 shows that in the rim of large forgings of 0.35 to 0.45% carbon steels, the hydrogen content had dropped to values below 1 ppm., which value approaches the limit of error in this method of determination.

By contrast, the hydrogen concentration in the mid-section of air cast steel ingots is higher. At the very center, values of 3 to 5 ppm. were found, while in the vacuum steel they were only 1 ppm. We believe that the air cast ingot was originally uniformly high in hydrogen, but during cooling the hydrogen has diffused out from the ends and surface of the forgings. Therefore only the data for the mid-sections show up the large difference between the air cast and the vacuum cast forgings.

**Volatiles From Ingots**—As has been reported by Americans operating vacuum melting equipment, we find a noteworthy vaporization of volatile metals or oxides which condense in the pump filters. An analysis of this dust showed 17.9% FeO, 47.0% MnO, 0.5% CaO, 1.1% SiO<sub>2</sub>, 1.4% Zn, 2.6% Cu, 0.2% Sn and 1.0% Pb. As yet we cannot evaluate the effect of traces of volatile elements like zinc, tin and lead. Certainly they would not be welcome in steel in measurable quantities.

#### Structure and Sonims

We have as yet found no evidence that the ingot segregation of carbon, phosphorus, sulphur and the usual alloying elements is influenced by vacuum treatment at pressures around 5 mm. On the other hand, oxygen and nitrogen in forging ingots, and in the forgings made therefrom, are definitely lower and no significant differences were observed between the top, middle and the bottom, nor between the rim and the core of the ingot. By contrast, the higher gas contents of air cast comparison ingots revealed major differences between rim and core and between top and bottom.

We are not sure that microscopic shrinkage (cavities) can ever be entirely avoided in large ingots or massive forgings. However, their number is unmistakably reduced by vacuum treatment, so far as the gas content is responsible for them.

(While this article relates to large ingots of low-alloy steels, supporting evidence is had from our experience with casting extremely thin sections, as for instance, the blade edges of Francis and Pelton water wheels made of 13% chromium steel. Porosity in these edges could not come from inadequate deoxidation, but only from the hydrogen content. By degassing the metal before casting, about 50% of the hydrogen was removed and porosity eliminated. Reduction from 8 to 4 ppm. evidently gives metal sufficiently low in hydrogen to render harmless any

Table III - Gases in Forging Ingots

	Ck 35	Ck 45	75 Mn 3	46 MnSi 4
Ingot size	21 tons	21 tons	25 tons	
Hydrogen*, air cast	6.3	5.0		
vacuum cast	2.4	1.4		
Oxygen†, air cast	0.007	0.001	0.003	0.004
vacuum cast	0.002	0.002	0.001	0.001
Nitrogen†, air cast	0.006	0.007	0.0065	0.007
vacuum cast	0.004	0.006	0.0065	0.005

†In weight percent.

\*In cc. at standard conditions per 100 g. of metal.  
Multiply by 0.9 to convert to ppm.

natural reabsorption during the run through the mold.)

Figure 5 shows some comparisons between insoluble residues in samples from vacuum cast and air cast 0.35% carbon steel ingots—a split heat. The quantity of oxides in the vacuum cast ingot was only one-fourth that in the air cast ingot. Furthermore, there were major differences in the silica and alumina contents, and manganese oxides were practically absent from vacuum cast metal.

#### Flakes

The following plant tests were carried out with a view to clarifying the very important question as to how far the liability to flaking is reduced by the decrease in hydrogen through vacuum degassing. A number of tops and bottoms from big forgings in current production were cooled in air immediately after forging and tested supersonically over the whole length, and also by etching of surfaces and by breaking off large pieces, in order to detect any flaky cracks.

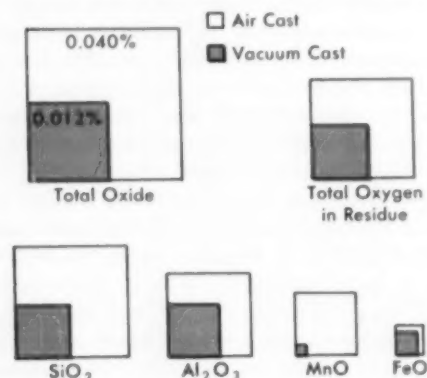
Several heats of 0.45% C steel were cast in 21-ton ingots by the two methods. Forging butts 18 in. diameter by 40 in. long from six such comparison pairs were air cooled. None of the vacuum cast metal showed any flakes; all of the air cast metal did. The same result was found in larger air cooled pieces from another split heat; these were 30 in. diameter and 14 ft. long. Two forgings from two 100-ton ingots of air hardening Ni-Cr-Mo steel such as used for electrical rotors, vacuum cast, were air cooled with surface hardening cracks but without internal flaking; one was 18 in. diameter and 55 in. long. On the other hand an 18-in. round, 5 ft. long, made from an 80-ton ingot of Mn-Si steel, cast in air, was flaky.

This proves that our original aim was achieved, namely, to avoid the tendency to flaking, even in heavy forgings.

To lend additional weight to this conclusion some tests on rails may be cited from our early work, since the relationship between that type of flake, which develops internal transverse fissures in service, and hydrogen is universally recognized. Rails are plain high-carbon steels with tensile strength of about 130,000 psi. In our comparisons, one part of the heats was cast without previous vacuum treatment; the other part, after stream-droplet degassing, was cast into 2-ton ingots in air. The ingots were then rolled to rails. Half of the rails were cooled slowly in a pit, the other half laid out in the open air. All the rails in the pit were free of flakes irrespective of method of casting. About 25% of the air cooled rails that were from the normal casts showed numerous flakes over the whole length. Only about 5% of the air cooled rails made from degassed steel revealed a few flakes. Thus the reduction of the hydrogen content in the molten steel from 5.8 to 3.1 ppm. had clearly reduced the liability to flaking—but, owing to the rolling and cooling strains, it was evidently not sufficiently low to prevent all flaking. Later we found that by further lowering the pressure during vacuum degassing, we could bring the hydrogen down to approximately 1.8 ppm. This metal was completely free from flakes after rolling into rails and cooling in air.

These experiments on rails demonstrate that caution must still be observed when degassed forgings are air cooled. It has been established that liability to flaking is influenced not only by the hydrogen content, but also by working, cooling and transformation strains. In some air hardening steels used for heavy forgings, these can induce flakes. Air hardening steels frequently

Fig. 5 - Comparison Between Amounts of Oxide Particles From Equal Samples in a 21-Ton Split Heat of 0.35 C Steel, One Vacuum Degassed, One Cast in Air



show surface cracks at minor defects which intensify the transformation stresses. For instance, the air cooled forgings of the Ni-Cr-Mo steel mentioned above showed hardening cracks over their whole length. The fact that they were nevertheless free from flakes is evidence of their particularly low hydrogen content after the vacuum ingot degassing.

When making heavy forgings from such steels it is necessary, therefore, to interrupt the air cooling of the piece at about 600° F. and to soft anneal it, or cool it slowly down to room temperature. According to our experience, however, this soft annealing need not be continued as long as is usual and necessary for normal air cooled ingots to diffuse the hydrogen throughout the ferrite. After preliminary machining, heat treatment involving quenching in air or in oil will be safe.

We have never found flakes in the current production of forgings from our vacuum ingots.

#### Mechanical Properties

The mechanical properties are likely to be influenced by the vacuum treatment by reducing the oxide inclusions. Furthermore, as is shown by the pickling embrittlement, low hydrogen contents also improve the toughness, though no change is shown in the tensile strength.

To check these principles, a large-scale evaluation was made of tensile and notched-bar impact values of test pieces cut radially from inductor shafts of a Ni-Cr-Mo steel with about 80,000-psi. yield point and 100,000-psi. tensile strength. To facilitate comparisons, only forgings of similar dimensions and of the same kind of steel and melting process were included.

Figure 6 shows that on the average the products of elongation and tensile strength and the products of reduction of area and tensile strength are higher in the forgings from vacuum ingots and that their range is narrower than in the air cast ingots. No influence of method of casting was revealed in the products of notched-bar impact value and tensile strength (right hand diagram).

Since no special precautions were taken in these inspection tests as to hydrogen diffusion during sampling and storage, it cannot be definitely decided whether this improvement of the values indicated in Fig. 6 must be attributed solely to a reduction of the hydrogen content,

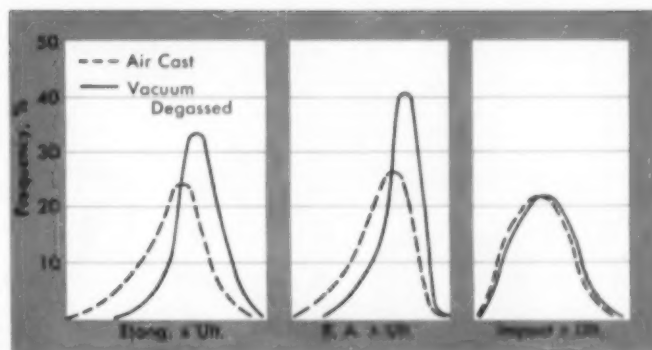


Fig. 6—Comparison of Mechanical Properties of Radial Test Pieces from Electrical Generator Shafts 24 to 37 In. Diameter. Forgings were made from 57 ingots weighing 16 to 47 tons, and 27 ingots weighing 50 to 100 tons, about equally divided as to method of casting

or partly to some improved degree of purity.

Supersonic recordings from these flake-free forgings from degassed steel show a definite improvement. The quality of inductor shafts, turbine rotors, backing rolls, high-pressure casings, barrel shafts and dies has also improved from the outset. Scrap figures have been considerably lower than in our previous experiences with air cast ingots.

When we began to apply the vacuum process to very heavy ingots it was necessary to adapt the steelmaking operations to the special requirements of the new casting method. This was successful, and surprisingly satisfactory results are now being achieved.

From the above it will be seen that vacuum casting has been successfully practiced in the production of heavy forging ingots. Hydrogen content has been reduced to such an extent that there is no longer any of the flaking always existing when using the normal metallurgical methods. These low hydrogens are achieved by dispersing the stream of metal into droplets in a vacuum. Other advantages of the Bochumer Verein's vacuum casting method are that the workmen can observe and direct casting without exposure to great heat and dust, the oxygen and nitrogen contents of the steel are low, porosity is reduced and mechanical properties are improved. The method has considerably increased the safety of large pieces of metal used in critical services. This is of special importance, since the production of large steam and gas turbine shafts, also rotors for electrical machinery, is one of the most difficult tasks of today's engineers. ●




## Light Metallurgy...

### If This Be Treason, Make the Most of It

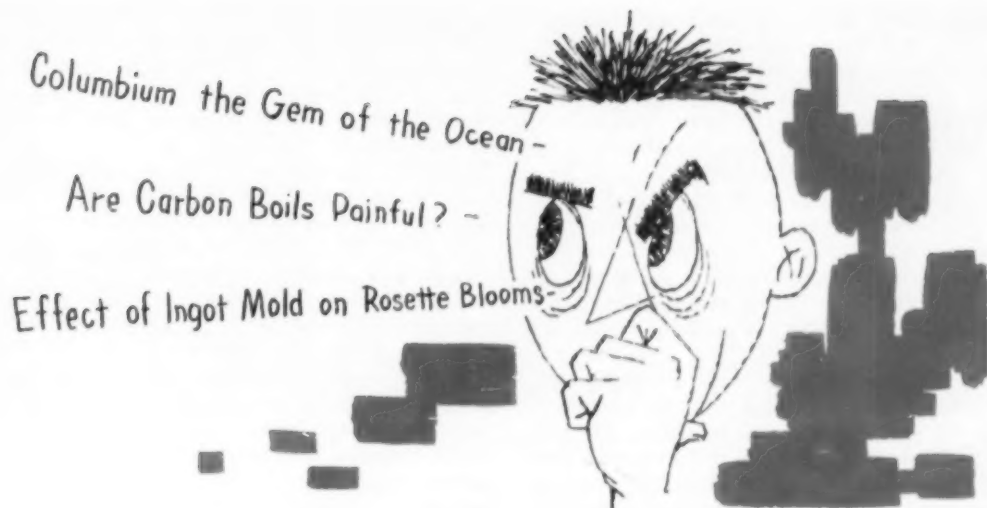
By S. J. MANGANELLO

**T**HIS MESSAGE of encouragement is dedicated to those deserving members of the metals industry who are frequently called up to explain metallurgical terminology to half-interested laymen directly or indirectly implicated with metal—pots and pans, paper clips, pipe cleaners, partial plates, electric trains, ferris wheels, bar rails, or you name it. This menagerie includes not only the wives, children, and relatives of the metal worker, but also new secretaries and typists, salesmen, visitors to the mills or laboratories, as well as buddies at the local gin mills. Most of these people have been exposed at one time or another to one or several metallurgical terms, scientific or otherwise—mostly otherwise.

To initiate an apparently intelligent conversation with, for example, a metallurgist, one of

his brothers-in-law may ask, "Why is columbium the gem of the ocean?" or, "Why is green sand black?" Questions like these elate the metallurgist, for he realizes immediately that the person asking the questions has never read the front section of the  Metals Handbook, 1948 Edition (Adv.). The metallurgist will then assume a professional air, flick the ashes from his cigar, and embark upon some deeply involved answers to these "very good" questions, perhaps beginning by telling his brother-in-law that columbium is now known as niobium.

Then the new secretary arrives! She wants to learn all there is to know about metallurgy in her first month of work. Her first question may be, "Is this word tuming or telming?" to which, of course, you answer, "Teeming". A



week later she may ask, "Do damping experiments rust iron?" A few weeks later she may ask, "Do descaling baths remove fish eyes as well as scale?" Consider her fully trained when she asks, "Are carbon boils as painful as sand scabs?"

You no doubt have listened to the radio game, "Twenty Questions". Imagine yourself a contestant in a somewhat similar game. Test your skill and patience with these twenty questions:

1. Will pressure vessels ever replace kayaks for low-temperature marine applications?
2. Does a slab of pig between two rolls constitute a plate lunch?
3. Do belt grinders also fabricate brass buckles?
4. Does tin cry when it is upset?
5. Will keyhole notches prevent gates from being dragged off?
6. What is the maximum temperature to which chilled iron can be heated and still be termed chilled iron?
7. Will season cracking destroy the germanium ingot crop this year?
8. What effect does ingot mold have on rosette blooms?
9. Can hairline cracks and skull scabs be cured by heat treatments to the skelp?
10. Will the divorced eutectic receive her antimony in the form of gold dust or uranium stock?
11. Is the creeping stage a normal phase in the aging of steel?
12. Will rediscovering the lost wax process pay dividends on the investment?

13. Does fatigue have any bearing on metal becoming shot?

14. What famous mill processes the grain from which hydrogen flakes are made?

15. Did stress and strain cause the Austenite twins to separate?

16. Are orange peels susceptible to lime boils?

17. Did sleeve markings have any bearing on the recent seizure and investigation of admiralty brass?

18. Was it the temperature or the humidity that caused Alpha Martensite to lose his temper while drawing?

19. Why does lead go to pot when the heat is on?

20. Will the Neumann band, the energy band, the forbidden band, or the deformation band ever replace the hardenability band as the main attraction at the National Metal Show?

Have you had enough? Consider yourself fortunate if you've never been put on the spot with these or similar semikilled questions. If some drunk insists that Sobieski was the famous Pole figure who invented the nonferrous wheel, agree with him. Spare yourself wasted effort. You should realize by now that tin pests and pinheads ain't welcome in bars.

In fact, I've come to the nonmetallic conclusion that it's a waste of time going to college to learn metallurgy. My friend, Captain Queeg, never went to college, yet he's evolved a method of rolling steel balls. Then there's myself, Andy Carnegie. Me and my cell mate, Captain Jones here, used to — oops! here comes that pesty whitecoat attendant again. Cu later!

## Stocks of Nuclear Explosives\*

THE UNITED KINGDOM now has enough nuclear explosive in its own possession to destroy every large city in the world and probably most of the large towns as well. The United States stockpile of Pu and  $U^{235}$  is enormously larger. The military bomb production of the U.S.S.R. is probably nearer to the American than the British production.

In Great Britain plutonium is produced in the nuclear reactors at Windscale in Cumberland.  $U^{235}$  is from the diffusion plant at Capenhurst where the two isotopes of natural uranium are separated. Almost exactly 5 kg. of either of these materials is necessary to make a bomb. A smaller mass will not explode.

The most direct hint of British production was contained in Sir Christopher Hinton's disclosures about the chemical plant at Windscale. He said that the amount of plutonium recovered each year was "measured in hundreds of kilograms" and that "hundreds of tons of uranium" from the Windscale piles was processed each year.

Each ton of natural uranium which goes into the reactors there contains 7 kg. of  $U^{235}$ . During the operation of the reactors this is partly converted into plutonium. For each kilogram of  $U^{235}$  a little more than 0.1 kg. of Pu is recovered. This means that for each 100 tons of uranium fuel, the explosive for 15 atomic bombs is recovered. The fuel charge of the piles can be estimated from the dimensions and suggests that the number of bombs produced is between 60 and 100.

The Windscale plant started continuous operations at the end of 1950. This means that it has made enough plutonium for 300 to 500 atomic bombs.

Estimating the production of the diffusion plant at Capenhurst is more difficult. It is known that the first charge for the prototype fast reactor at Dounreay is to be of  $U^{235}$  and that this will weigh just over 3000 kg. of explosive or the equivalent of 600 bombs. This is believed to be roughly half its production for the two years since the preparation of the White Paper on atomic energy and the time when the charge will have to be ready (at the end of this year).

On this hypothesis the Capenhurst plant produces about 600 bombs a year. Its operation has not, however, been free from trouble, so it has probably produced explosive for somewhere between 2000 and 3500 bombs.

Thus, altogether our stockpile is enough to make between 2300 and 4000 bombs. Not all of this is made up into weapons of course, though material for at least 1000 bombs has been so committed.

**The U.S.A.**—In the United States the main source of plutonium is the eight large reactors at Hanford, Wash. The first of these started up in the summer of 1944 and the last three were in operation

before the beginning of 1955. Altogether there have been more than "50 pile-years" of operation, each of which would have produced material for more than 50 atomic bombs. This means that there are probably at least 5000 plutonium bombs in the United States.

American uranium bombs come from the thermal diffusion plant at Oak Ridge, Tenn. This began work in 1944 and has since been enormously increased in size. According to one congressional indiscretion its consumption of electricity amounts to 10,000,000 kw.—roughly half the present total installed capacity of power stations in Great Britain.

In August 1955 in Geneva the U.S. Atomic Energy Commission announced that it would lease enriched uranium to countries which signed bilateral agreements at \$25 for each gram of  $U^{235}$  contained in the material. It is understood that this charge springs largely from the cost of electricity used in making it. The cost of T.V.A. electricity in Tennessee is small, probably no more than 0.5¢ per unit. By this argument it must take rather more than 2,000,000 kw. of electricity to produce a bomb, so the Oak Ridge plant must produce at least one and probably two bombs an hour.

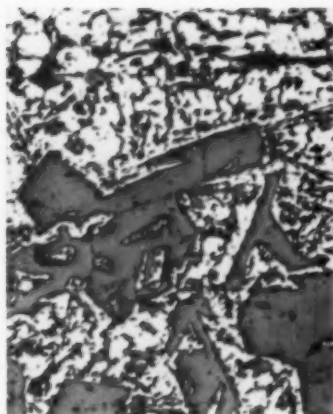
This means that its production of bombs probably amounts to about 7500 a year at present, or in the ten years for which the plant has been in operation (at first on a smaller scale) it cannot be far short of 30,000 bombs.

**U.S.S.R.**—In Russia things are inevitably harder to discover. The bad design of the Russian power station described at Geneva suggests that they had no large reactors before about 1953. Most of their nuclear explosive must come from a diffusion plant somewhere. But if the figures in the reports of the Russian five-year plans are to be trusted, the total installed capacity of electrical generators in the Soviet Union is not enough, when industrial demand is taken account of, to allow them to operate a thermal diffusion plant comparable to Oak Ridge. However, the U.S.S.R. must have had one working since the end of 1946. Probably it is larger than that at Capenhurst. Probably the Russian stockpile is enough for 10,000 bombs.

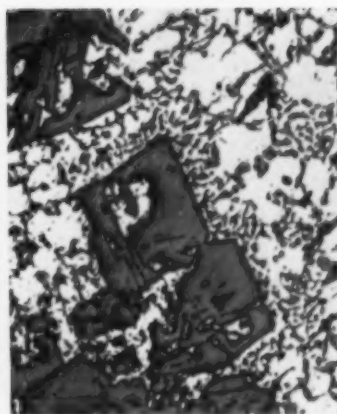
Calculations like this inevitably contain large uncertainties. Nevertheless other information, like the relative cost of producing bombs in thermal diffusion plants and reactors, is consistent with these conclusions. It is certain that the stockpile of nuclear explosive in all three countries is much larger than has previously been thought.

Indeed perhaps it is sufficiently large to make the military think it is large enough for all foreseeable military purposes.

\*From an article "By Our Scientific Correspondent" in *Manchester Guardian Weekly* for March 1, 1956; reprinted by permission.



Unmodified



Modified With Sodium



With Dilute Phosphor Copper

Fig. 1 — Segregation of Silicon in 22% Si Aluminum Alloy Cast in Permanent Molds. Hydrofluoric acid etch; 100×

## High-Silicon Aluminum Casting Alloy

By JOHN C. WAGNER\*

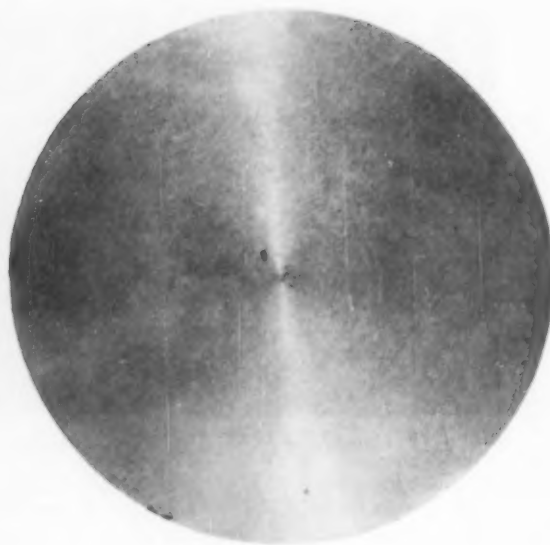
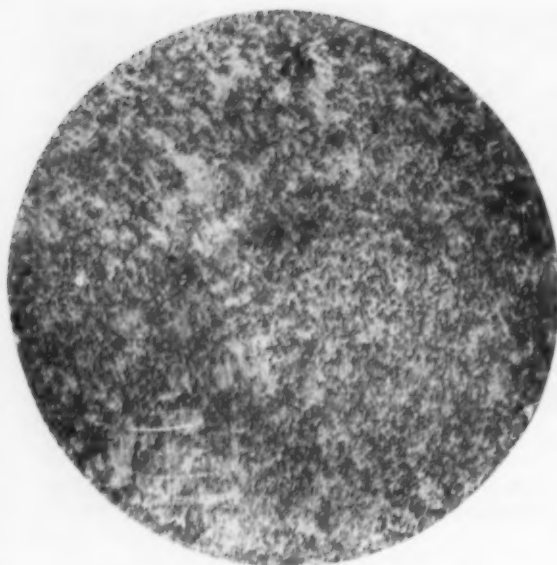
Addition of dilute phosphor copper to a high-silicon aluminum casting alloy reduces segregation and increases machinability. (E 25, G 17, Al)

**P**ISTONS for automotive engines are usually made in this country from the aluminum casting alloys, A 132 and D 132 which contain 12 and 9% silicon, respectively. In Europe, an alloy with 22% silicon is being used whose thermal expansion is closer to that of the cast iron engine heads and whose wear resistance is much greater than that of the American alloys. In one instance, a truck company reported that there was no perceptible wear of pistons made from the 22% silicon alloy after 100,000 miles of service.

Unfortunately, the high silicon content causes excessive segregation and coarsening of the hypereutectic silicon particles, and castings are diffi-

cult to machine and sometimes unpredictable in performance. Several foundries have attempted to overcome these difficulties by the use of modifying agents such as phosphorus pentachloride or sodium and its salts but these additions have some disadvantages. Phosphorus pentachloride is especially objectionable because of the heavy unpleasant fumes given off when it is added to molten aluminum alloys. Sodium and its salts are difficult to control and lose their effectiveness if

\*Materials Div., Research and Test Dept., U.S. Naval Ordnance Plant, Indianapolis, Ind. (now in the Metallurgical Department, Allison Div., General Motors Corp., Indianapolis.)



*Fig. 2 - Comparison of Machined Surfaces of Unmodified (Left) and Modified Aluminum-Silicon Alloy (Right)*

the metal is held molten for any appreciable time after the addition is made. The effectiveness may disappear completely after only 15 to 20 min. holding time.

Dilute phosphor copper has been suggested as an additive and a recent investigation at the U. S. Naval Ordnance Plant has indicated that it reduces both hypereutectic coarsening effect and segregation without any adverse effect on other properties. The cost of the addition is only about half a cent per pound of aluminum alloy cast and its effect persists in remelting.

The basic alloy contains 22% Si, 2% Ni, 1% Cu, 1% Mg, 0.5% Fe, 0.1% V, balance Al. When no modifier is added, its as-cast structure contains the coarse segregate shown at the left in Fig. 1. Metallic sodium additions reduce the size of the segregate, but not enough as shown in the center. Addition of dilute phosphor copper (right) both refines and disperses the hypereutectic silicon. Phosphorus in the modified alloy is 0.01%.

Twenty laboratory and several commercial foundry heats of the modified alloy have been made. Castings in a variety of shapes ranging in size from  $\frac{1}{8}$  to 2 $\frac{1}{2}$  lb. have been poured in both sand and permanent molds. Melting and pouring temperatures were varied from 1380 to 1500° F. and the alloy has been held molten for as long as 2 $\frac{1}{2}$  hr. after modification. All permanent-mold castings were fine-grained and free from segrega-

tion. Sand castings were materially improved, but the modification was not so satisfactory. Commercial fluxing and degassing compounds had no adverse effects on the properties of the modified alloys.

Machinability of the material was checked by comparing the tool life in tapping before excessive wear occurred. Holes were drilled in permanent mold castings with a No. 43 drill and then tapped on a drill press equipped with a tapping head. The taps were size 4-40, class 2 and were made from high speed steel. A total of 1200 holes were tapped and 25 taps were expended. Tap life was determined by measuring the threads with an NC-2 thread plug gage. If the tapped hole tapered so that two threads of the plug gage were above the surface, the tap was rated worn out. An increase of 300% in tap life was obtained by addition of phosphor copper to the alloy.

Additional machinability tests were conducted with carbide tools. In these, the greatest improvement was noted in surface finish as shown in Fig. 2. With the unmodified alloy, the cutting tools caused pitting as a result of dragging out large particles of silicon. Little or no pitting occurred when the modified alloy was machined.

Modification by dilute phosphor copper apparently eliminates certain detrimental properties of the high-silicon alloy when cast in permanent molds, and its use in this country should increase. The greater wear resistance and lower thermal expansion should be beneficial not only in pistons for heavy-duty engines but also in other automotive components.



This is the cell room in ELECTROMET's new electrolytic manganese plant at Marietta, Ohio.

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**Analysis:** Manganese 99.9% min. (on metallic basis)

**Nitrogen-bearing Grade**—approx. 93% manganese  
approx. 6% nitrogen

Dehydrogenated material is available.

**Packaging:** Usually packed in steel drums holding 500 lb. of material. Smaller packages available at small premium.

For further information about ELECTROMET electrolytic manganese metal, and other ELECTROMET ferro-alloys and metals, please contact the nearest ELECTROMET office listed below.

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In Canada: Electro Metallurgical Company, Division  
of Union Carbide Canada Limited, Welland, Ontario



## Correspondence...

### On the Importance of Reading the Handbook Supplement Carefully

CLEVELAND

Back in early 1955 when the first Handbook Supplement had been in the hands of the members about nine months I was working with titanium and needed an etchant more convenient to handle in the laboratory than the usual hydrofluoric-nitric acid mixtures.

Since that great source of metallurgical knowledge—the American Society for Metals—was within reach via a 10¢ phone call I called Ray Bayless and asked him where I could get some good information on titanium. He referred me to the Handbook Supplement. I did not know that I had one. I was told in

crisp but friendly phrases that if I paid more attention to what was sent by the A.S.M., I wouldn't be looking all over the town for what I already had!

Greatly chastened, I carefully read the chapter on titanium. The usual etching reagents were listed in a table but under "corrosion resistance" on page 84, column 2, line 10, is this highly informative clause, "all concentrations of oxalic acid attack the metal".

So I dumped about 20% oxalic acid in some water, put my titanium forging in it, placed it on a hot plate and waited for action which came soon but not immediately. Somewhere between 80 and 100° F. rapid etching takes place with technical grade acid and Lake Erie water on at least two titanium alloys. Chemically pure acid and distilled water react very slowly. Forging

flow lines and some defects show more clearly than with other etching solutions. The great advantage is that you can etch titanium with something that won't burn holes in your pants.

A final suggestion: Since oxalic acid is sometimes produced naturally in the human body, some mysterious attacks on titanium may be attributed to handling.

D. WHITE

### Quantitative Metallography by Lineal Analysis

STANFORD, CALIF.

During recent years interest has been increasing in techniques and equipment for rapid, reproducible quantitative analysis of microstructures. Both point counting and lineal analysis techniques are considerably superior to visual estimation of the volume fraction of the various microconstituents in a polished and etched section. Lineal analysis with the Hurlbut counter is more reproducible than the photographic point counting technique and has the additional advantages of ease and speed of operation.

Several other methods of lineal



*Top—Titanium Alloy Forging Etched 15 Min. in 20% Oxalic Acid at 200° F. Bottom—Same Titanium Forging Repolished and Etched in 10% Nitric Plus 2% Hydrofluoric Acid for 20 Min. at 120° F.*

# P&H Welding Positioners offer these 9 BIG ADVANTAGES

*Exclusive P&H features make welding easier, safer,  
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**1. Greater Flexibility.** P&H Positioners have plus clearance when face plate is tilted 135°. You can handle larger weldments.

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Please send me more information on  
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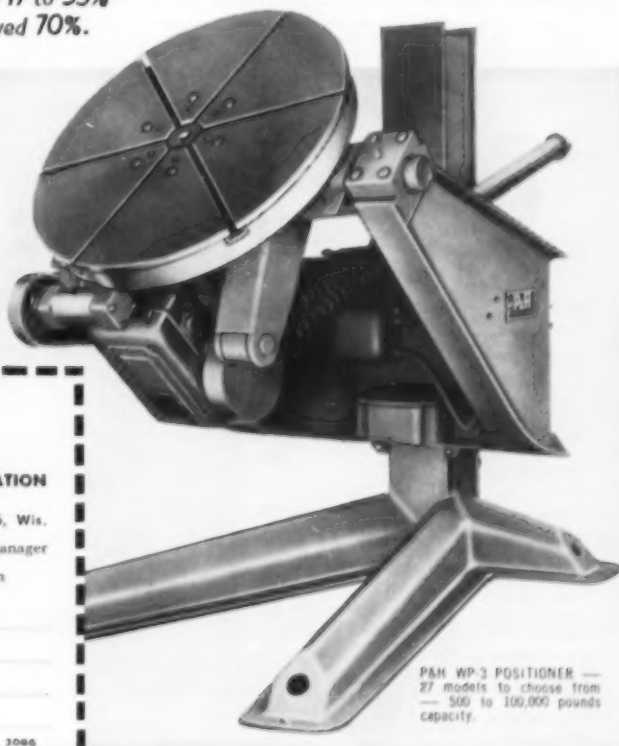
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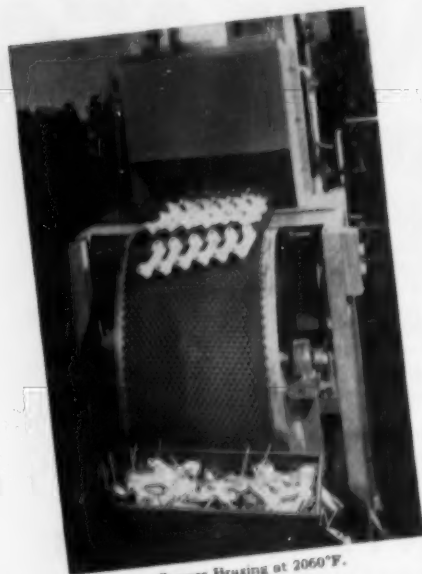
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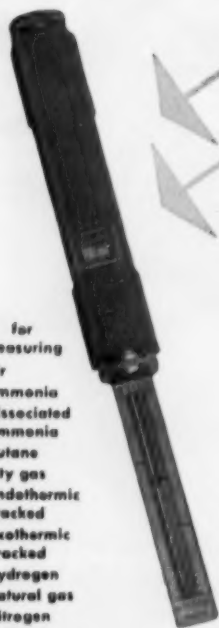
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For additional information request bulletin #201.

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## Metallography...

analysis have been developed such as the incorporation of several micrometer heads onto a single-stage micrometer shaft, a variation of which has recently been offered by one of the manufacturers of optical equipment.

In our laboratories we have been using an alternate lineal analysis technique. This method depends upon the accurate measurement of the length of time that a given micro-constituent appears under the ocular crosshair as the specimen is moved across the microscope field at a constant velocity. Two pieces of equipment are required—one to move the specimen at constant velocity and the other to record the measurements. We use a variable speed transmission coupled to an electric motor with a reducer gear box to move the specimen. This simple drive mechanism is suspended in such a manner that the shaft can be connected to one of the stage micrometer knobs of a Reichert metallograph by a short length of heavy-walled rubber hose. To disengage the drive, we just rotate the stage and remove the hose.

The other portion of this lineal analysis equipment is also simple. It consists of several electric stop clocks of the accumulating type, each of which is run by a sensitive microswitch. For convenience, all of the microswitches (push buttons) are mounted in a row in a single control box. Each button controls a single clock, and when depressed, starts the clock. Upon release, the clock stops. The procedure is to assign a particular button (and clock) to each microconstituent, and while the specimen is moving across the field of the microscope, to depress the button corresponding to the constituent passing under the crosshair at that particular time. At the conclusion of a given traverse the ratios of the accumulated times on the stop clocks are equal to the volume ratios for the individual constituents. The clocks can be reset to zero and the procedure repeated to give the precision desired.

This technique, in which the driving and measuring systems are separate, has an advantage over the Hurlbut method in that there is no mechanical jarring of the optical

**"The right quench oil for our work is**

# **SHELL VOLUTA OIL 23"**

says Garland Wilcox, Chief Metallurgist  
Wallace Barnes Co., Bristol, Conn.

## **...the story of a profitable change**

WALLACE BARNES COMPANY and steel springs have "gone together" for nearly a century. Most of today's output is in SAE 1075 or 1095 steel.

Because the quenching operation is so important to the life of springs, the Wallace Barnes laboratory decided to test its regular quenching oil against some of the newer products, including Shell Voluta Oil 23. This is what they found:

Shell Voluta Oil 23 showed a superior quench rate, with correct hardening and relative freedom from distortion. It drained more rapidly from the quenched parts, re-

ducing dragout loss. It washed off more completely in the alkaline cleaner; it reduced flaming, and cut down on the oil baked to parts.

Wallace Barnes reports that this oil has almost eliminated trouble with "slack-quenched parts," and that heavier stock now goes through without special handling. So . . . Shell Voluta Oil 23 has replaced the former quench oil in all tanks of the spring hardening departments, serving salt pot lines and shaker hearth furnaces.

We'll be glad to provide full information on Shell Voluta Oil 23.

WALLACE BARNES CO.  
A division of Associated Spring Corp.  
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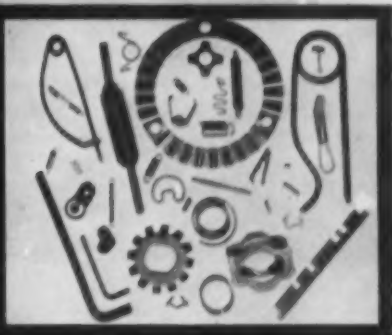
Photos courtesy "STEEL"



Shaker hearth furnaces automatically dump parts into Shell Voluta Oil 23, then remove and drain them.



Flat springs at austenitizing temperature get a fast quench in Shell Voluta Oil 23.



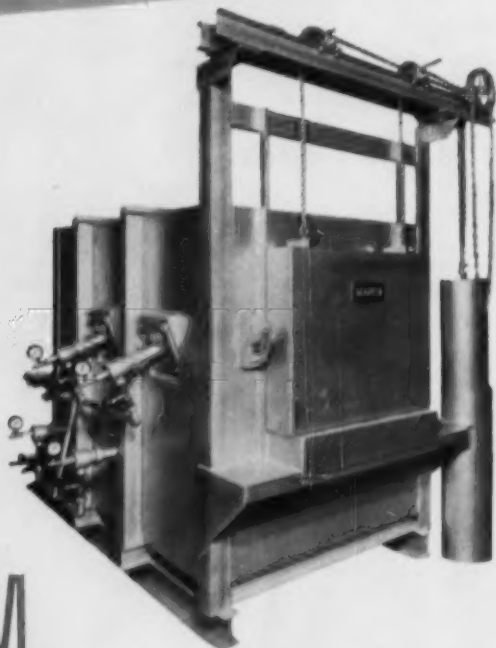
Over 35,000 prints of production items like these are kept on file at Wallace Barnes Co.

## **SHELL OIL COMPANY**

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## Metallography . . .

system when disengaging one counter and engaging the next. In addition, there is no problem of mechanical inertia because electric stop clocks of this type have a very effective brake. As a matter of fact, the problem of inertia is the only reason that inexpensive self-starting household clocks cannot be used for this work. With sensitive microswitches, the limit of accuracy is set by the reflex time of the operator.

In all instances, of course, the quantities that are being measured are those seen as a result of the metallographic techniques of polishing and etching, and are absolute values only if those metallographic techniques reveal the structure in its true proportions.

ROBERT A. HUGGINS  
Asst. Prof. of Metallurgy  
Stanford University

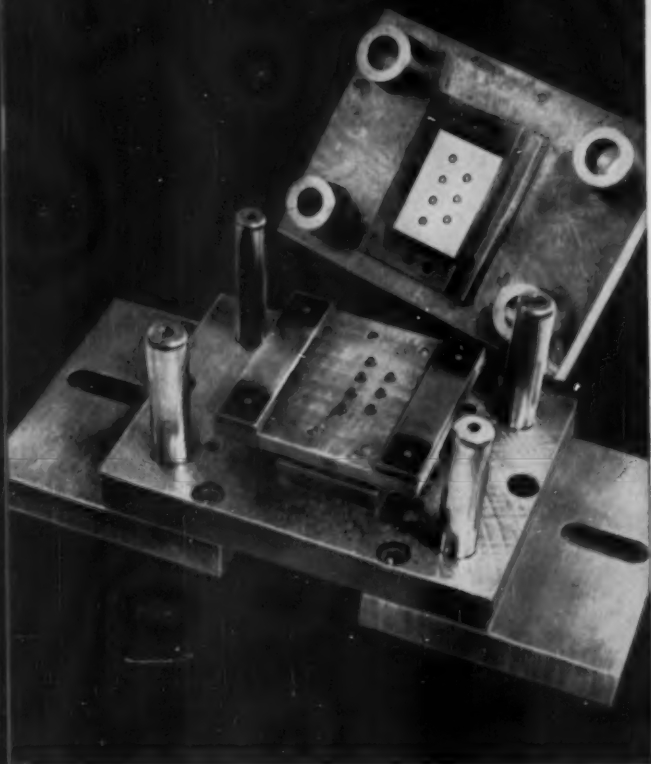
## Nitriding in Air

JAMSHEDPUR, INDIA

We have also observed precipitation similar to that described by Reed Knox, Jr. in the November 1955 issue of *Metal Progress*, when steels containing substantial amounts of acid-soluble aluminum are heated in an atmosphere of nitrogen. The size and distribution of the needle-like phase depend on the concentration of aluminum and nitrogen in steel. Such precipitation is readily visible only when aluminum in the steel exceeds or is in the neighborhood of 0.38%. The needle-like phase was identified as AlN by X-ray diffraction and it was also established that no iron nitride was present.

We believe that the needles depicted in the photomicrograph shown by Mr. Knox may be of AlN and the steel in which he obtained the needles may be high in acid-soluble aluminum and nitrogen. It may be worth while analyzing the AlN content of his steel and tracing back its melting history particularly relating to its deoxidation by aluminum. It is also probable that aluminum may have been inadvertently introduced into these steels. Although the steels in this instance were heated in air, nitrogen may have been absorbed from fuel gases

## FIELD REPORT: NO. 87



### WHICH DIE STEEL WOULD YOU USE HERE to boost production per grind 500%?

These tools blank out dead soft brass washers, .170" O.D. x .100" I.D., .009" thick, on a punch press at 186 strokes per minute. It is an exacting job for a couple of reasons. First, it involves a government contract and strict delivery schedules have to be maintained. Then too, the punch and die are set up to blank seven washers per stroke and have to do this for many millions of pieces . . . and still remain within burr limitations set up by the government. Performance from the steel used in the past was far from satisfactory . . . to maintain schedules, production had to be substantially increased.

Suppose the decision were up to you. Which die steel would you be willing to recommend for steady, trouble-free production?

In this Field Report from customer files, here's what happened: The Carpenter Matched Set Diagram was consulted and Carpenter No. 610 (Air-Wear) was selected. Since then No. 610 has enabled the Company to hold delivery schedules comfortably . . . racking up increases in production per grind as high as 500%. And this is especially significant when you realize that five

hours' downtime is involved each time the tools have to be reground. Total parts to date: 5,500,000 . . . and the tool is still good for about 15 regrinds of .003" each.

Why make the tough decisions alone, when Carpenter's service organization is sincerely interested and equipped to work with you? A move in the right direction would be to call your nearest Carpenter Mill-Branch Warehouse, Office, or Distributor, now.

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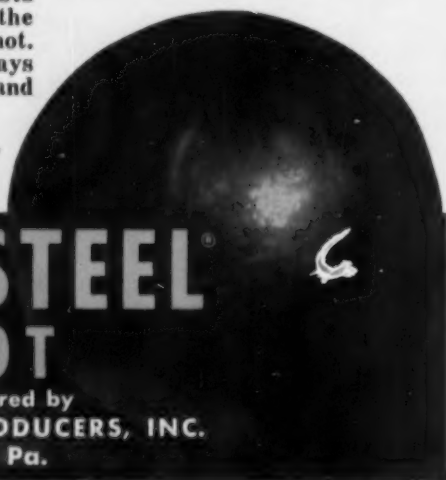
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## Nitrogen . . .

in the soaking pit and also to some extent during air heating.

Commenting on the last few lines of Mr. Knox's letter we believe that mild steel will capture nitrogen when heated to the high-temperature austenite region, if the steel contains high acid-soluble aluminum. It would be worth while to analyze the nitrogen contained as AlN in the steels used by Mr. Knox.

B. R. NIJHAWAN  
Deputy Director  
National Metallurgical Laboratory

CONSHOHOCKEN, PA.

The observance of Dr. Nijhawan that AlN needles are readily visible only when aluminum in steel is close to or above 0.38% is interesting but seems to preclude the possibility that the acicular phase appearing in the photomicrograph on p. 126 of the November 1955 issue of *Metal Progress* is AlN since the steel shown is a rimmed steel containing 0.017% acid-soluble aluminum. I have found a similar precipitate in aluminum semikilled steels containing about 0.024% acid-soluble aluminum.

Evidence that the needle-like constituent is iron nitride was provided by heating a microspecimen containing the needles obtained from the torn edge of a capped steel blooming mill slab for 40 min. at 1075° F. and water quenching. (See microstructure in Fig. 1, p. 102.) As shown in Fig. 2, the needles dissolve in the ferrite during heat treatment, a fact which is consistent with the known solubility of iron nitride in alpha iron. Aluminum nitride would probably dissolve only in gamma iron at temperatures above 1900° F.

It is probable that the apparent nitrogen pickup which I found in defective blooming mill slabs can be explained partially, and sometimes wholly, by the mechanism of auto-nitrification suggested by G. H. Enzian in the May 1956 issue of *Metal Progress*. If it is assumed that the ingot contained exposed blowholes while in the soaking pit, oxidation of the walls of these holes probably decreases the volume of metal between them, thereby causing concentration of nitrogen in the remaining surface metal. Narrowing of the spaces between blowholes and tear-



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## Nitrogen . . .

ing of the surface during hot rolling might exaggerate this effect. I have noticed that the nitride precipitation seems most intense in narrow slivers of metal isolated from the surrounding steel by deep heavily oxidized cracks. On the other hand, an ingot with exposed blowholes, by virtue of its greatly increased surface area relative to that of a sound ingot,

might be expected to absorb more nitrogen from the surrounding atmosphere than a sound ingot. I still believe, on the basis of experiments reported in the November 1955 and May 1956 issues of *Metal Progress*, that such absorption does occur irrespective of the aluminum content of the steel.

REED KNOX, JR.  
Research Metallurgist  
Alan Wood Steel Co.



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The tip of beryllium copper, turned to an initial fit of 0.0005" clearance, and subjected to constant pounding of 150-160 cycles per hour and to temperature extremes of 1200°F. aluminum

and the effects of the water cooling system, operated without sticking or excessive wear. It was once used through an entire 8-hour shift without water cooling!

The advantages of "BERYLCO" beryllium copper—thermal conductivity, wear resistance, and ductility—make it the ideal metal for use in plunger tips. For specific details of this application, request Technical Bulletin #29.

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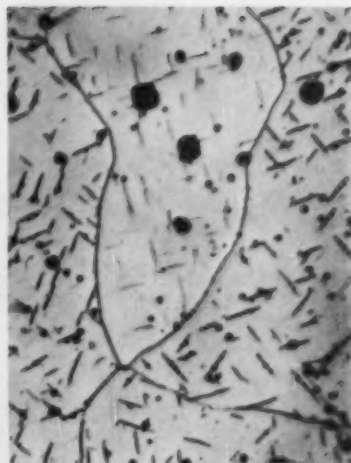


Fig. 1—Iron Nitride Precipitate Found in Blooming Mill Slab

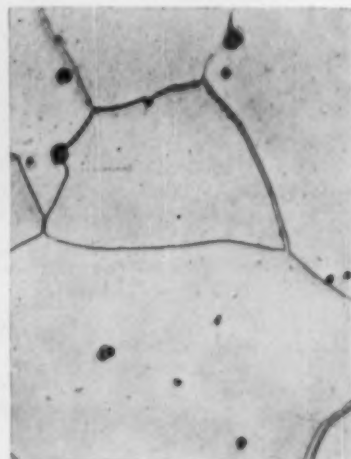
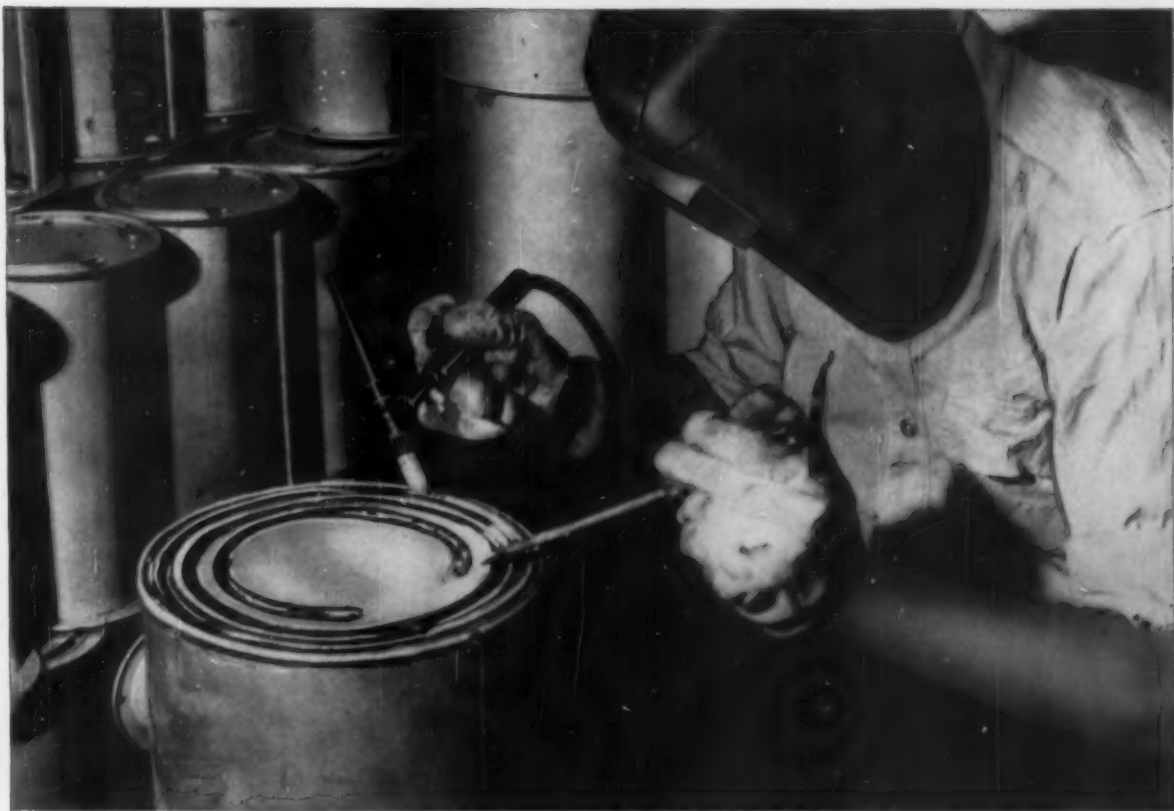


Fig. 2—Heating at 1075° F. Will Dissolve Iron Nitride

## More on Indian Research

NEW YORK CITY

I was surprised to read in the April issue of *Metal Progress* C. L. Mantell's reaction to my article on metallurgical research in India. According to Mr. Mantell, I had claimed that the National Metallurgical Laboratory had developed new processes for the production of low-carbon ferrochromium, high-purity manganese dioxide and electrolytic manganese. No such claims were made. The exact statement was, "Among the processes developed to the stage of commercial exploitation are the production of low-carbon ferrochromium, manufacture of high-purity manganese dioxide and elec-



MULTIMET alloy wraps are joined by welding in the fabrication of aircraft cabin heaters.

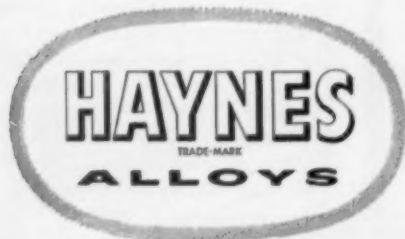
## MULTIMET Alloy Wraps Absorb the Heat from a 3500 deg. F Flame

MULTIMET alloy wraps are used to absorb the intense heat from burning aviation gasoline in aircraft cabin heaters. The spirally wrapped alloy sheet transfers the combustion heat to fresh ventilating air. Very thin sheet—only 0.025 in. thick—does an excellent job here despite the high metal temperatures and the oxidizing conditions.

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MULTIMET alloy is one of many HAYNES high-temperature alloys for economical use over a wide range of operating conditions. It has given good service for engine manifolds, turbine blading, heat-treating equipment and many aircraft components. For a copy of a booklet describing HAYNES high-temperature alloys, and for prices and sizes of MULTIMET alloy, get in touch with the nearest Haynes Stellite Company office.



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**The Cambridge Wire Cloth Company**



Department 8  
Cambridge 6,  
Maryland



OFFICES IN PRINCIPAL INDUSTRIAL CITIES

## Indian Research . . .

trolytic manganese. . . ., from indigenous material." I was frankly puzzled as to how Mr. Mantell arrived at his interpretation of this straightforward statement. Incidentally, the only reference to new processes was under the section on industrial laboratories and referred to research work on new processes and techniques in steelmaking.

R. F. BUNSHAH

Associate Engineering Scientist  
New York University

## Patent Office Needs Young Engineers

NEW YORK CITY

With the demand for young engineers in America being what it is, it may be idle to point out another place where they are sadly needed — yet I will do so because of their lack in a certain place where American industry is facing long delays in products and processes otherwise ready for market. The number of patent applications is growing far faster than the number of patent examiners.

The patent examiner thus holds a key position in the advancement of American technology. A hundred new men have been added to the examining staff of the U.S. Patent office and 300 more are wanted in 1956.

Patent examiners pass upon application for patents in a wide range of technical fields to determine whether they are novel and whether invention is involved. This calls for a study of the existing patent and related scientific literature. There are good opportunities for rapid advancement, and to carry on graduate studies at the same time.

Salaries for examiners start at \$4345 a year and work up to \$7570 in five years. Eventually salaries of \$13,000 are available.

Engineers and scientists holding a college degree in engineering or applied science are eligible for appointment without examination, upon application to the Commissioner of Patents in Washington, D.C.

HENRY E. SHARPE

Vice-Chairman

New York Patent Law Association



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These original baskets are still operating at maximum capacity after **FIVE YEARS** of continuous use. Each basket shown above is 37" in diameter by 22" deep and when fully loaded contains over 1½ tons of track bushings. The complete load of three baskets is in excess of 4½ tons.

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# Personal Mention



**S. C. Massari**

**S. C. Massari** has been appointed director of research of the National Engineering Co., Chicago.

A native of Chicago, Mr. Massari received his metallurgical education at Massachusetts Institute of Technology. After graduation in 1924, he was placed in charge of quality control of zinc sheet and strip at the Illinois Zinc Co., Peru, Ill. In 1926 Mr. Massari became chief metallurgist for the Association of Manufacturers of Chilled Car Wheels, Chicago, and held this position until 1942 when he was called to active duty in the U.S. Army. Serving in the Chicago Ordnance District, Mr. Massari was appointed chief of the tank-automotive branch and later received the Legion of Merit in recognition of his services. After release from the Army, he accepted the position of technical director of the American Foundrymen's Society. Further recognition was awarded Mr. Massari in 1949 when he received the John H. Whiting Gold Medal "for outstanding contributions in the field of ferrous metallurgy". In 1953 he left the Society to become manager of the foundry division of Hansell-Elcock Co., Chicago, and held that position until joining the National Engineering Co.

Last month Mr. Massari presented the Charles Edgar Hoyt lecture at the American Foundrymen's Society Castings Congress and Show.



**John G. Thompson**

On February 29, 1956, a large group of metallurgists, chemists and scientists met at Tilden Gardens in Washington, D. C., to honor a man who was in one person metallurgist, chemist and scientist. Many telegrams were received from others who could be there only in spirit. The occasion was a testimonial luncheon to **John G. Thompson**, who was retiring from his post of chief of the metallurgy division of the National Bureau of Standards after putting in more than 35 years in governmental service.

Born in Eau Claire, Wis., Thompson received his doctorate in chemistry from Cornell in 1921 and immediately joined the Bureau, and remained there with steadily rising responsibilities (except for a five-year stretch with the Fixed Nitrogen Laboratory working on the synthesis of ammonia). He succeeded the late Henry Rawdon as chief of the Bureau's metallurgy division in 1946.

Much of his work in the 1930's centered on the production of 99.99% pure iron, and involved such related problems as the slip casting of beryllia crucibles and the perfection of the vacuum-fusion method for determining gases in metals. During World War II he supervised a group working on the metallurgy of uranium (for which he received the War Department's award) and another group of studies on beryllium and

beryllium-aluminum alloys for the War Metallurgy Committee.

John Thompson has served many years on the executive committee of the Washington Chapter, and was chairman in 1942-43. He has also been a member of several of the standing committees of the American Society for Testing Materials, and of the Materials Advisory Board of the National Research Council. His future plans are unannounced, other than to take a breather and a look-around.

**Armand J. Andre** has been named to the newly created position of assistant sales manager, southern division, E. F. Houghton & Co., Philadelphia. Joining Houghton in 1939, Mr. Andre served as a representative in the Chicago sales division until his recent appointment. His headquarters are now in Charlotte, N. C.

**Claude Belleau**, formerly laboratory supervisor at Sorel Industries, Ltd., Sorel, Que., is now research metallurgist for the Chrysler Corp., Detroit.

**Nicolas W. Baklanoff** has retired from Battelle Memorial Institute, Columbus, Ohio, and moved to Florida. However, Mr. Baklanoff is still retained by Battelle as a special consultant.

**Frederick W. Rys**, formerly assistant manager of the Freyn Dept., Engineering and Construction Div., Koppers Co., Inc., Pittsburgh, has been elected vice-president of Koppers International, C. A. Mr. Rys is also manager of construction projects with Koppers International. **John F. Black** has replaced Mr. Rys as assistant manager of the Freyn Dept. Mr. Black's previous position was manager of continuous casting sales with Koppers Co.

**George Bidigare** was recently promoted from chief metallurgist, Packard Motor Car Co., Detroit, to director of manufacturing research, Studebaker-Packard Corp., Detroit.

**James H. Bly** has joined the sales division of High Voltage Engineering Corp., Cambridge, Mass. Prior to this position, Mr. Bly was division manager of X-Ray, Inc., Detroit.

# Look into **REVERE** Phosphor Bronze

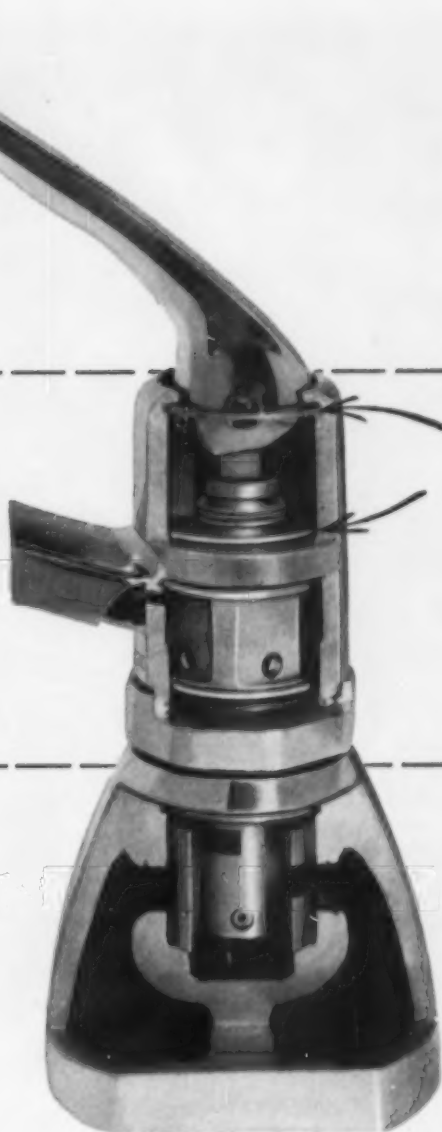
—it pays  
**RAVENNA**  
to use it!

This Moen Single Handle Mixing Faucet contains an anchor disc and an anchor washer, both stamped out of Revere Phosphor Bronze Strip. These are small parts, but in a fine product such as this faucet, high quality metals must be used throughout. Here is a condensation of the manufacturer's experience with the phosphor bronze:

*Anchor Disc:* •Standard punching speed maintained. •No pre-straightening off the arbor for the automatic punching process. •No excessive die wear. •Corners are sharp and clean; no de-burring needed. •Natural mill finish is better than they could achieve by tumbling or burnishing. •High tin content means no lubrication is required; they call it "silent brass."

*Anchor Washer:* •Have not had a single surface failure. •Dry tumble to de-burr. •Good fatigue characteristics and no obvious signs of corrosion.

Revere offers several types of phosphor bronze, each with slightly different characteristics. In addition to this alloy, Revere also supplies Ravenna with round and octagonal leaded brass tube and free-cutting brass rod, for use in various parts of the valve. We will be glad to collaborate with you on selection of just the right forms of the correct alloys for your products, present or projected. See the nearest Revere Sales Office.



Moen Single Handle Mixing Faucet, made by Moen Valve Co., Division of Ravenna Metal Products Corp., 6518 Ravenna Ave., Seattle 15, Wash.

## **REVERE**

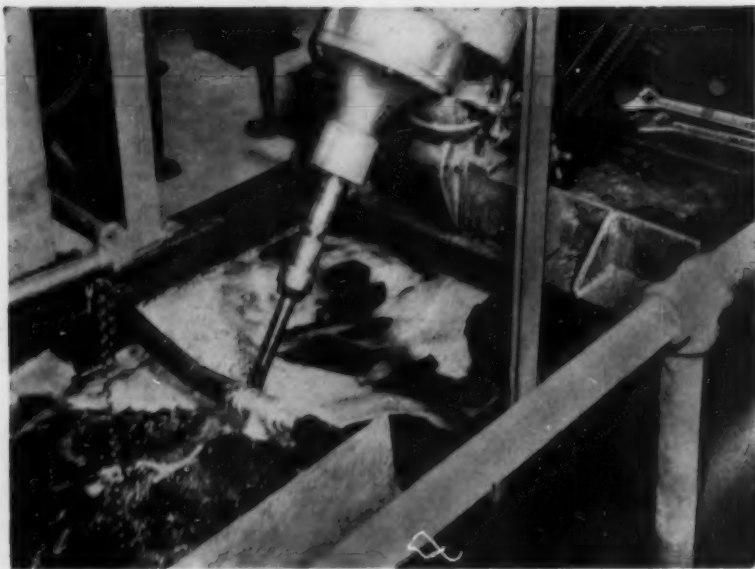
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"The Revere Four-Way Service" is a 16 mm. sound motion picture in color, educational and informative. If you haven't seen it, write nearest Revere Office.



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If you're considering *violent turbulence* for your quenching operations, we'd like to drop this reminder:

Most of the people who use violent agitation in the quench bath do it with **LIGHTNIN Mixers**.

And without exception, these men report good heat treating results. Greater uniformity of hardness, all over the part and from one part to the next. Greater depth of hardness, resulting in higher over-all tensile strength and toughness. No re-treats and rejects due to soft spots. No warpage or cracking. For some steels, better machinability.

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For information on the number, size, type, and cost of **LIGHTNIN**s you will need to get the results you want, just call your nearest **LIGHTNIN** representative (listed in Thomas' Register) or write us today.

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Mixers**

**MIXING EQUIPMENT Co., Inc.**

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In Canada: Greer Mixing Equipment, Ltd., 100 Miranda Ave., Toronto 10, Ont.



**PERMANENT . . .** Often used as a component of new quench tanks and heat treating furnaces. Sizes 1/4 to 3 HP.



**PORTABLE . . .** These **LIGHTNIN**s fit existing tanks, and adjust easily to the best angle for uniform turbulence. Thirty models; sizes 1/8 to 3 HP.



**SIDE ENTERING . . .** For large quench tanks; single or multiple installation. Sizes 1 to 25 HP.

## Personals . . .

**Robert K. Beck** is executive vice-president and director of the Brush Beryllium Co., Cleveland. Prior to this Mr. Beck was president and director of the Apex Smelting Co., Chicago.

**Andrew Foulds, Jr.** has left his position with American-Standard Research to become a metallurgical engineer in the reactor metallurgy department at Battelle Memorial Institute, Columbus, Ohio.

**Frank W. Schaller** is now employed as a research engineer in the physical metallurgy section of the metallurgical department, scientific laboratory division, the Ford Motor Co., Detroit.

**Charles Widstrand**, formerly section supervisor of the physical test section, Ford Aircraft, now heads the Meta-Pro Co.

**Herman S. Rosenbaum** is employed as a research assistant with the General Electric Research Laboratory, Schenectady.

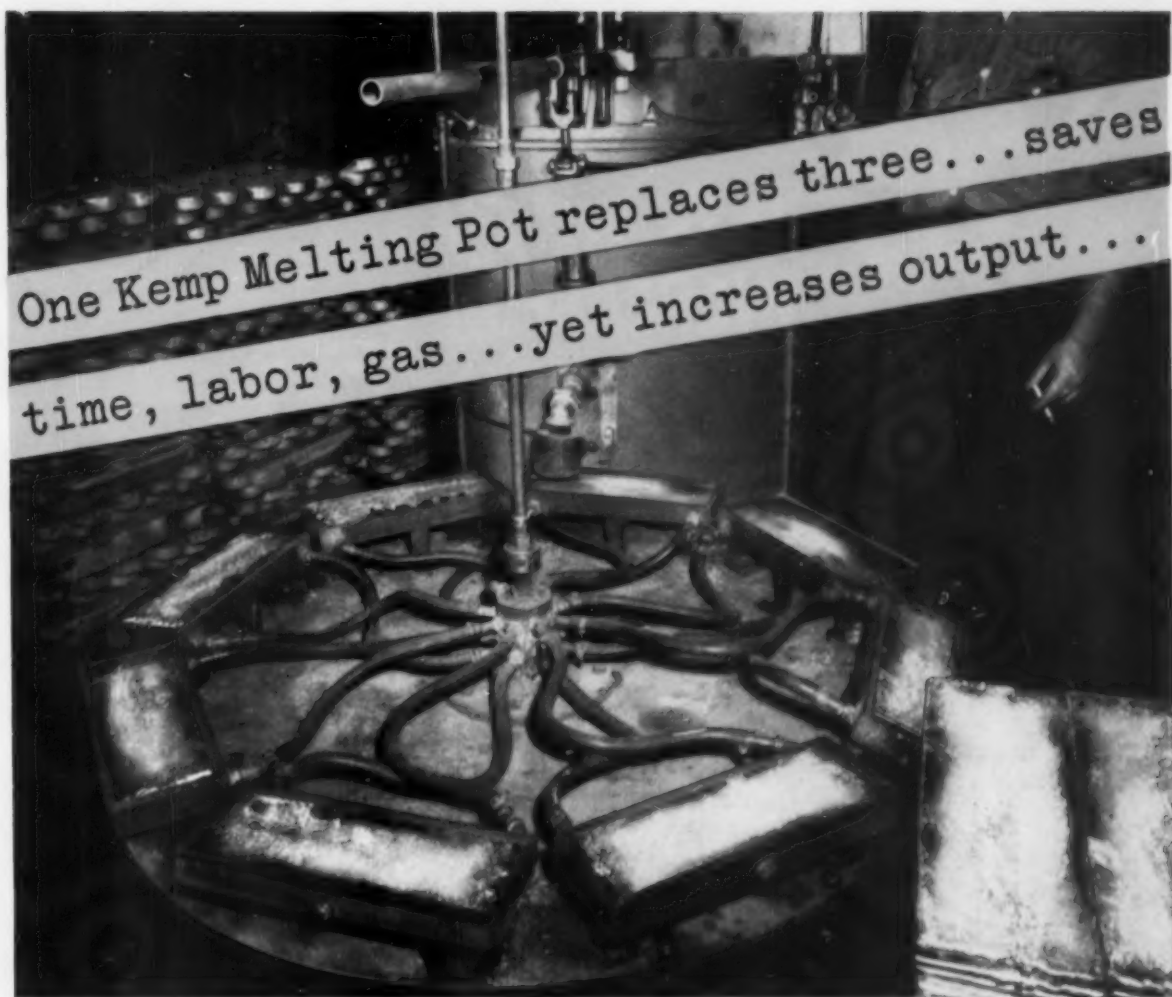
**Paul T. Kelley** has been promoted to chief process metallurgist for the Youngstown, Ohio, district of U. S. Steel Corp.

**Trevor Heard** has organized his own company, Erin Technical Sales, Toronto, Ont., to promote brass forgings for use in oil, gas, refrigeration and plumbing industries.

**William E. Taylor** has been appointed chief engineer in the materials research department, semiconductor products division, Motorola, Inc., Phoenix, Ariz.

**Peter J. Adzema**, formerly with Jones & Laughlin Steel Co., Pittsburgh, is now on active duty with the U. S. Army. Mr. Adzema is stationed at the Tokyo Ordnance Depot, Tokyo, Japan.

**K. L. Moazed** is studying for his Ph.D. in metallurgy at Carnegie Institute of Technology. Mr. Moazed also holds the position of project engineer in the metals research laboratory there. Before coming to Carnegie Tech, he was a research assistant in the department of metallurgy at Rensselaer Polytechnic Institute where he received his master's degree in February.



## **Sheffield Tube Corporation reports: Kemp Melting Pot melts 2,200 lbs. of lead per hour, eliminates down-time**

The Sheffield Tube Corporation, New London, Conn., manufactures tubes for toothpaste, cosmetics, drug specialties and similar products. Slugs for extruding are punched from thin lead sheets, which are rolled from moulded slabs. To melt large "pigs" for moulding these slabs, Sheffield formerly used three pots: two meltdown pots, feeding into a 1,276 lb. capacity holding pot. This equipment has been replaced by one Kemp Immersion Melting Pot, capable of melting 2,200 lbs. of lead per hour.

### **Kemp boosts production . . . cuts down-time**

Formerly, one man produced about 500 slabs daily; dross formation had to be removed two or three times daily; and the pots were replaced after anywhere from 6 weeks to 6 months of operation. With the Kemp Melting Pot, two men now mould

about 1,400 slabs daily. During the first 5 weeks of service dross was not removed once—and except for an occasional 10-minute valve-cleaning job there was no down-time at all.

### **Kemp can help you**

Whatever your application, it will pay you to investigate Kemp Melting Pots. You'll benefit in many ways: Kemp units are not subject to periodic and expensive breakdowns . . . offer greater heating surface, faster heat recovery, lower dross formation, lower room temperatures. Whatever your problem, Kemp units will help cut labor costs, eliminate lost time, increase output.

Find out how Kemp engineers can provide the most profitable solution to your heating or melting problems. Write for Bulletin IE-10 today.

# **KEMP** OF BALTIMORE



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CARBURETORS • BURNERS • FIRECHECKS • ATMOSPHERE  
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SINGING EQUIPMENT

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Tests with  
**INCREASED  
SPEED...**  
**Accurately**

Y Model Motorized  
Hardness Tester

Requires fewer  
operating steps... Because

### IT'S MOTORIZED

• Here is the motorized operating procedure made possible by the new WILSON "Rockwell" Y Model Motorized Hardness Tester—

- 1 Place specimen upon anvil or table.
- 2 Elevate test piece into test position. (With the new Set-O-Matic Dial Gauge, the large pointer will then automatically point to zero.)
- 3 Tap depressor bar to apply Major Load. When Major Load is fully applied, the Motorized Mechanism takes over—completes the test cycle—removes the Major Load.
- 4 Read "Rockwell" Hardness Number. Then, lower elevating screw to remove test piece.

For complete information about the WILSON Y Model, or any others of the complete line of WILSON "Rockwell" Hardness Testers, write or call today. A WILSON hardness testing expert is available to consult on your specific requirement. \*Trade mark registered



Illuminated Dial Gauge

(1) Affords clear and easy reading. Readings are easily taken wherever your "Rockwell" Tester is located—whatever the lighting conditions of the room. Indenter light (2) is directed towards the test area, making it easy to locate the exact area of test at all times.



Set-O-Matic Dial Gauge

The Set-O-Matic Dial Gauge increases the accuracy of the test, makes the test cycle shorter and increases the number of readings obtainable within a definite period of time.



Wilson Mechanical Instrument Division  
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## Personals . . .

John B. Burnham, Jr., ☉ has joined the metallurgy department of the research staff, General Motors Corp., Detroit, as research associate in charge of research on nuclear fuels. Prior to this, Mr. Burnham was in charge of the metallurgy group at the materials testing reactor, Phillips Petroleum Co., Bartlesville, Okla.

Thomas F. Conmy, Jr., ☉ is now a senior scientist assigned to the test reactor at the atomic power division, Westinghouse Electric Corp., Pittsburgh. Mr. Conmy was formerly a metallurgist at the Corning Glass Works, Corning, N. Y.

Robert B. Connell ☉, formerly district representative in Michigan for Babcock & Wilcox Co., has been appointed manager of sales for the central district of Titanium Metals Corp. of America, New York. Mr. Connell's offices will be in Chicago.

Robert B. Corbett ☉ has been named assistant to the president (technical) of the Heppenstall Co., Pittsburgh. An employee of the company since 1945, Dr. Corbett was named director of research in 1952, and will continue to hold this position, in addition to his present appointment.

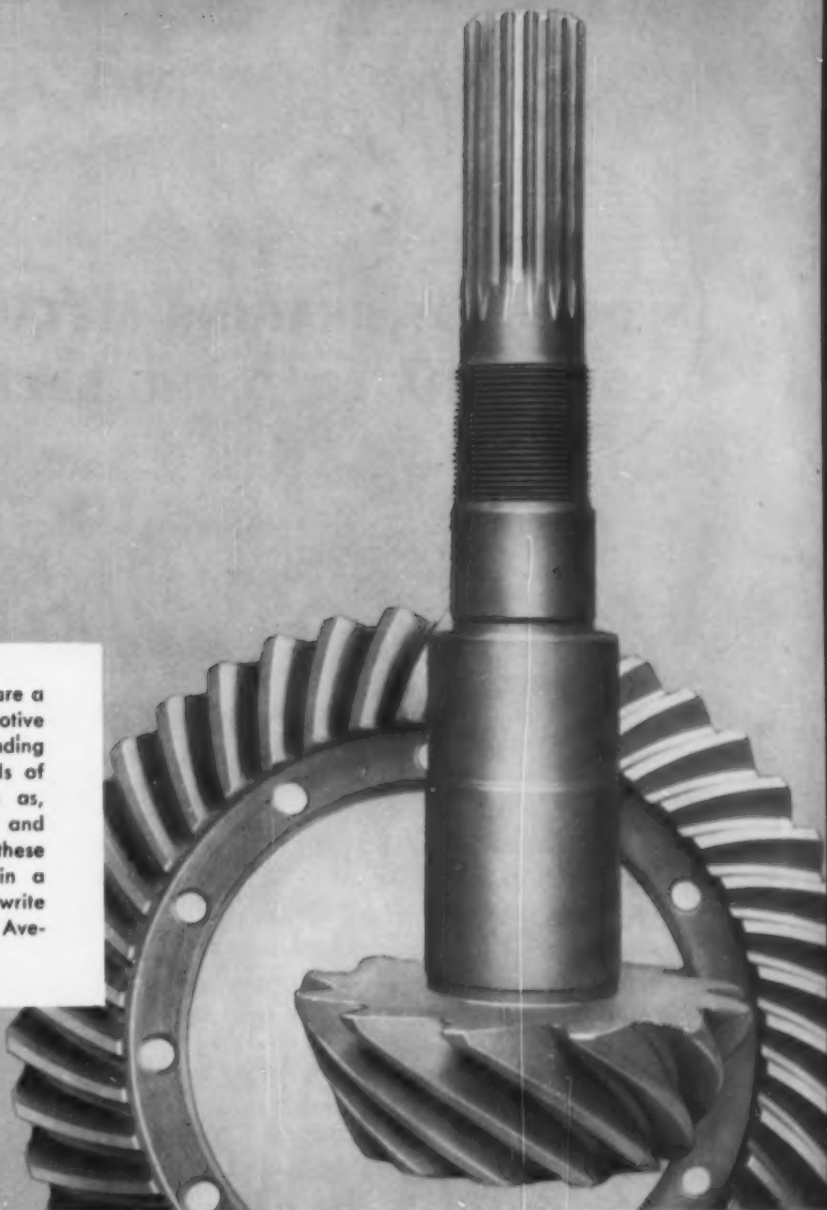
Theodore W. Daniels ☉ recently retired after 43 years as a roll maker. Since 1936, Mr. Daniels had been employed at the roll and machine works of the U. S. Steel Corp. in Canton where he last served as assistant general superintendent.

Dillon Evers ☉ has been appointed associate director of research, Mallory - Sharon Titanium Corp., Niles, Ohio. Dr. Evers was formerly associate professor of metallurgical engineering at Purdue University and supervisor of the University's physical metallurgical laboratories.

Leslie V. Whiton ☉ has announced the opening of an office in White Plains, N. Y., for consultation on the production and marketing of nonferrous metals. Before coming to the United States in 1955, Mr. Whiton was head of the metal sales development program for the Consolidated Mining & Smelting Co. of Canada, Montreal, Que.

"IT'S BETTER IF IT CONTAINS MOLY"

Moly carburizing steels with 0.5% Mo are a natural for components like this automotive ring-gear and pinion. They have outstanding properties that suit them to the demands of gearing and similar applications, such as, superior case hardness, low distortion and good machinability. Many features of these new carburizing steels are discussed in a recent technical article. For a reprint, write Climax Molybdenum Company, 500 Fifth Avenue, New York 36, N. Y., Dept. 5.



# Molybdenum Carburizing Steels

## MOLYBDENUM OFFERS THE ECONOMICAL KEY TO PERFORMANCE

Over the years, molybdenum carburizing steels have proved their merits in scores of applications and at every level of production.

**Design engineers** know moly steels for their uniform hardenability, toughness and wear resistance.

**Production men** know that moly steels are easy to heat treat, easy to machine.

**Management** knows that moly steels mean economy in fabrication, high performance in a wide range of end products.

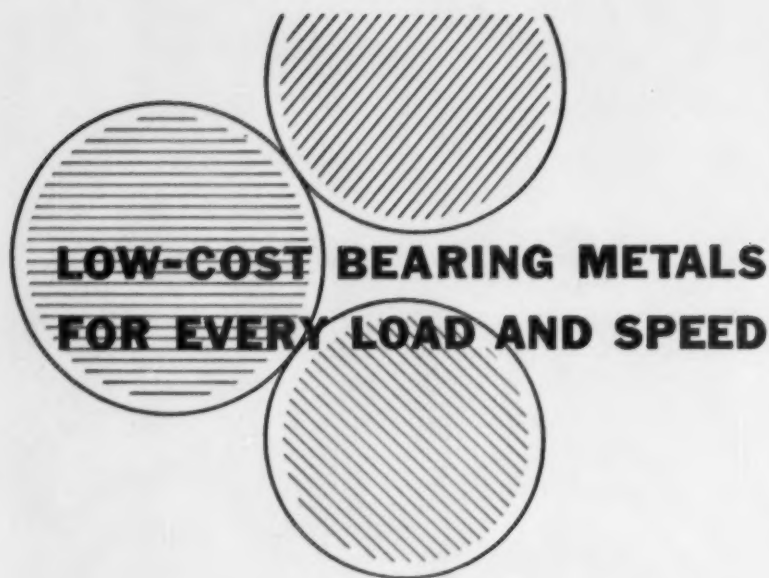
Standard molybdenum carburizing steels are widely available. Higher moly analyses may be ordered in heat lots from a number of leading suppliers.

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Moly Key  
to better  
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Copper alloys are traditional for friction bearings. There is at least one suitable for almost every kind of bearing application.

The familiar leaded bearing bronzes are easy to machine, and the soft lead in the hard copper-tin matrix acts as a lubricant under severe conditions. Federated copper-tin alloys have high compression strength. Aluminum bronzes withstand exceptional loads, speeds and temperatures and stand up well in difficult sliding operations.

Babbitts, which are bearing alloys having a tin or lead base, and which are bonded to a steel or bronze shell, offer good frictional properties, excellent running-in properties and good behavior where lubrication is poor or unreliable. Federated research has provided many improved babbitts for modern bearing service.

If your problem is the design of a low-cost friction bearing, Federated may be able to give you valuable suggestions. Our metallurgists work with many kinds of non-ferrous metals, and they know how to alloy them correctly to obtain the specific physical characteristics you require.

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## Personals . . .

**R. Buck Gray** ☉, a recent graduate of Pennsylvania State University, is now employed as a sales engineer in the Milwaukee, Wis., district sales office of the Aluminum Co. of America.

**John E. Decker** ☉, formerly employed by the U. S. Steel Corp. and National Forge & Ordnance Co., is night superintendent at Green River Steel Corp., Owensboro, Ky.

**Roger R. Turk** ☉ is now a research metallurgist with North American Aviation, Inc., Downey, Calif. Mr. Turk was formerly a metallurgist in the tungsten and chemical division of Sylvania Electric Products, Inc., Towanda, Pa.

**Thomas C. Junk** ☉ has been transferred from the heat treat department to the position of engineer in the manufacturing engineering section of the Sharon Transformer Plant, Westinghouse Electric Corp., Sharon, Pa.

**Jack L. Selk** ☉, formerly a materials and process engineer with North American Aviation, Inc., is now a materials and process engineer in a metallurgy group at the El Segundo plant of Douglas Aircraft Co., Inc.

**P. C. Mortenson** ☉ is now chief engineer of mobile products at Vickers, Inc., Detroit. Mr. Mortenson was previously administrative engineer, Western Hemisphere Engineering, Massey-Harris-Ferguson, Inc., Detroit.

**Stephen Foldes** ☉ has left his position as research metallurgist at the Beryllium Corp., Reading, Pa., and is now a metallurgist in the advance engineering group of the direct current motor and generator department, of the General Electric Co., Erie, Pa.

**Donald E. Coran** ☉, formerly a research metallurgist for Rohr Aircraft Corp., San Diego, Calif., is now chief metallurgist for the Industrial Research Laboratories, Los Angeles.

**Edward E. Billingham** ☉, recent recipient of a bachelor's degree from Purdue University, is working in the metallurgy department of the Lafayette, Ind., plant of the Aluminum Co. of America.

# WESTINGHOUSE SAVES \$18,043 with USS "T-1" STEEL

The Sunnyvale, California, plant of Westinghouse Electric Corporation builds unusual expansion bellows and huge wind tunnel air compressors. Steel bellows that flex, both up-and-down and sideways, form a means of effectively accommodating large thermal expansions between the compressor and the foundation. Westinghouse lopped an impressive \$18,043 off the cost of these bellows by switching to USS "T-1" Steel.

"T-1" costs less to machine. It costs less to weld. To top it off, "T-1"

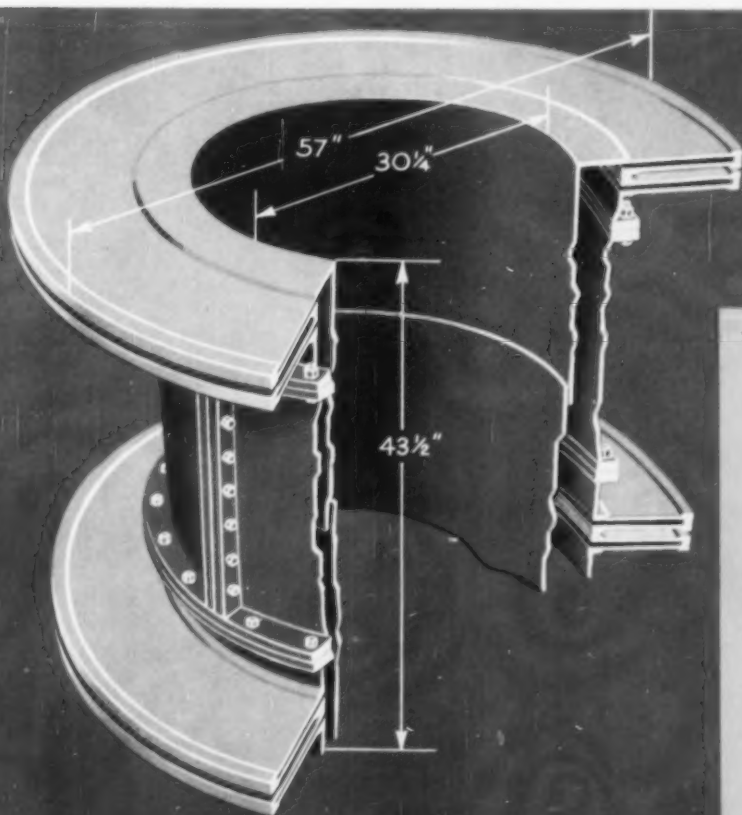
costs less to buy than the steel previously used. Yet it is plenty tough and strong enough to meet the rugged physical requirements.

## NEW WAYS TO SAVE MONEY

No other alloy steel can be used in so many ways to save money or improve products. Already—and "T-1" is still a relatively new steel—it has been used with great success in rotating machines, earth-moving equipment, towers, pressure vessels, mining machines, printing presses, and

other heavy-duty applications.


Think of USS "T-1" when you need very high tensile strength (105,000 psi.) and yield strength (90,000 psi.) . . . when you need good creep rupture strength at high temperatures . . . extraordinary toughness at sub-zero temperatures . . . resistance to abrasion, impact, and abuse. All or any of these properties, plus good weldability, are yours in "T-1"! For information write to United States Steel, Room 5299, Pittsburgh 30, Pa.



**A CUSHION OF STEEL.** Here is one of the bellow systems that are used on large wind tunnel air compressors. Two steel bellows at the top and at the bottom of the central cylindrical section flex, both up-and-down and sideways, to provide a means of accommodating large thermal expansions for the huge compressors. Tough, strong steel was needed for the bellows. USS "T-1" does the job better and, at the same time, saves money for the Westinghouse Electric Corporation.

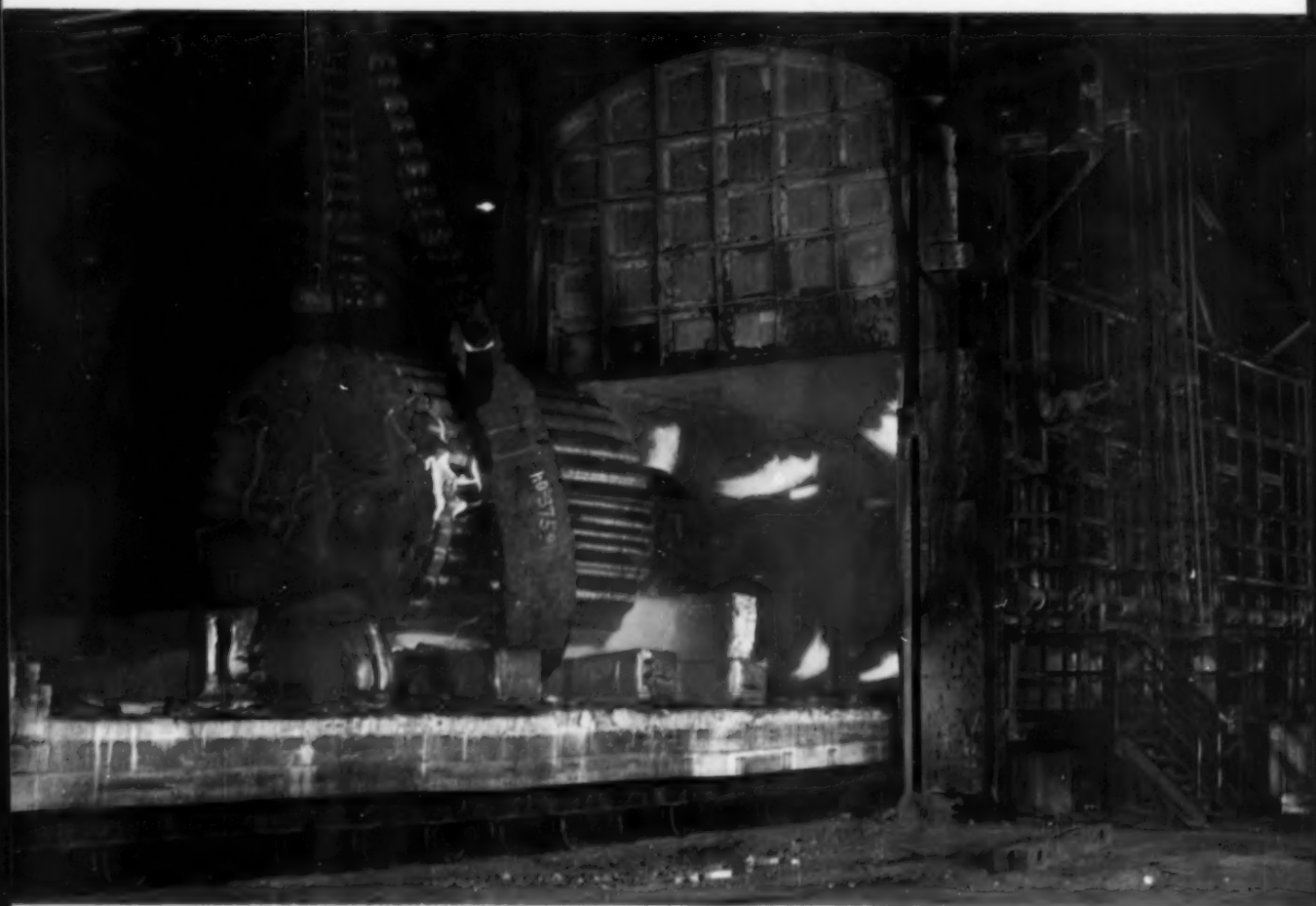


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USS **"T-1"** CONSTRUCTIONAL ALLOY STEEL 

UNITED STATES STEEL

# "I think forging is an art"

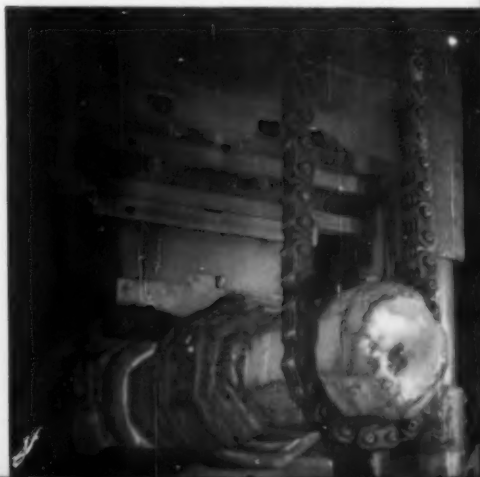


After about three days of heating, crane takes hot ingot to press.

Preliminary forging.  
Basic shape of forging is determined here.



Secondary forging.  
This is water wheel shaft for hydro-electric plant.





says **William C. Steele**

*U. S. Steel Superintendent of Forging and Heat Treating*

Forging an ingot is somewhat like sculpturing a statue by means of semaphore signals that you give to a lurching robot. Using only hand instructions, the forge shop pressman must blend the action of giant cranes, manipulator machines and the press itself. Working only with the immense, blunt dies of the press, he must knead the steel to develop its maximum strength, then squeeze it into the most intricate shapes, frequently to a quarter-inch tolerance.

Truly, this is an Art.

At our Homestead Forgings Division, William Steele has complete charge of the production floor where USS Quality Forgings are forged and heat treated. He has worked in the

Division for 28 consecutive years, producing such things as special armor plate, compound-curved wind tunnel parts, hollow sleeves, precision rolls and machinery parts so complicated that you'd never believe they could be forged from a monstrous ingot of solid steel.

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Heavy machinery parts—carbon, alloy, stainless

Forged steel rolls and back-up roll sleeves

Electrical and water wheel shafts

Specialty forging of all types

### UNITED STATES STEEL

Final inspection. Piece has been heat treated, machined and subjected to dozens of critical tests. Now, it's a USS Quality Forging.





**REFRACTORY CONCRETE** lining in this forge furnace is made with Lumnite cement. Furnace manufacturers—Champion Blower & Forge Co., Lancaster, Pa.

## Tough test for Refractory Concrete

Forge furnaces are tough on refractories because of the extreme variations in temperature and thermal shock due to rapid heating and cooling. Experience has shown that Refractory Concrete made with Lumnite® cement gives excellent service in forge furnaces—also in other furnaces of many types, both large and small. Refractory Concrete has demonstrated its durability under severe temperature and service conditions. With it you can easily place your own refractory installations, and service strength is reached within 24 hours. A convenient way to make Refractory

Concrete is with castables. These are packaged mixes of Lumnite calcium-aluminate cement and selected aggregates designed for your specific job, prepared and distributed by leading manufacturers of refractories.

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L-122

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against dust, dirt,  
and chipping!**

**The new**



**electrode  
end-caps!**

National Carbon's new protective end-caps perform a dual function. They screen out dust and dirt from electrode socket...protect against end-face chipping—two common causes of impaired electrical performance. They also give better visibility, quicker identification, easier handling and storage of graphite electrodes from 12-24 inch diameter. National Carbon's new electrode sales and service program serves you in many ways:

**HERE'S HOW:**

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*Technical Service:* Largest, best qualified group of its kind...organized to extend the service function regularly furnished by field salesmen. Repeatedly, this service has recommended improvements in electrode operation...improvements which have resulted in more efficient power utilization, better joints and joining procedure, and attractive dollar savings for customers.

*Free Electrode Training Program:* Conducted in your own plant or any other mutually convenient location. Streamlined demonstration program familiarizes your men with the important *do's* and *don't's* of electrode usage.

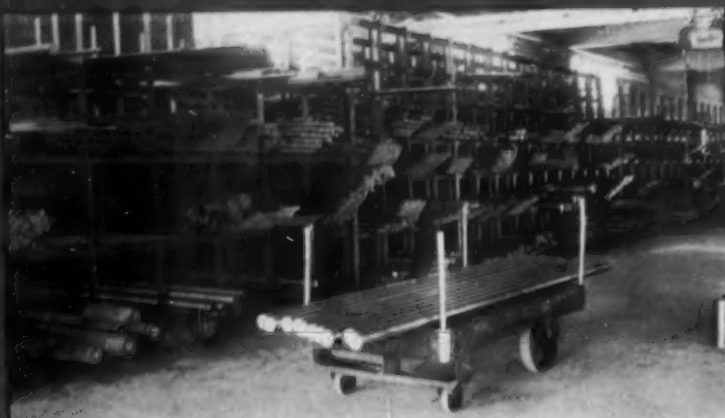
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\* Leaded and Non-leaded



## PETERSON STEELS, INC.

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## Personals . . .

**Ernest Grider** is now attending the middle management training program at the Harvard Business School. After the completion of the program, Mr. Grider will return to his position at the Utica Drop Forge & Tool Corp., Utica, N. Y.

**Rennie J. Swope**, a recent graduate of Michigan State College, has joined the research staff of the technical center at General Motors Corp., Warren, Mich.

**J. Trotter Thompson**, formerly openhearth plant and contact metallurgist with Follansbee Steel Corp., Follansbee, W. Va., is contact metallurgist at Newport Steel Corp., Newport, Ky.

**William R. Miller** was recently named district sales manager in Dayton, Ohio, for Universal-Cyclops Steel Corp. Mr. Miller was formerly with the Carpenter Steel Co.

**Nathan J. Hoffman**, a 1955 graduate of the Colorado School of Mines, is now a research engineer in the materials and processes group of the Rocketdyne Division of North American Aviation, Inc. in Los Angeles.

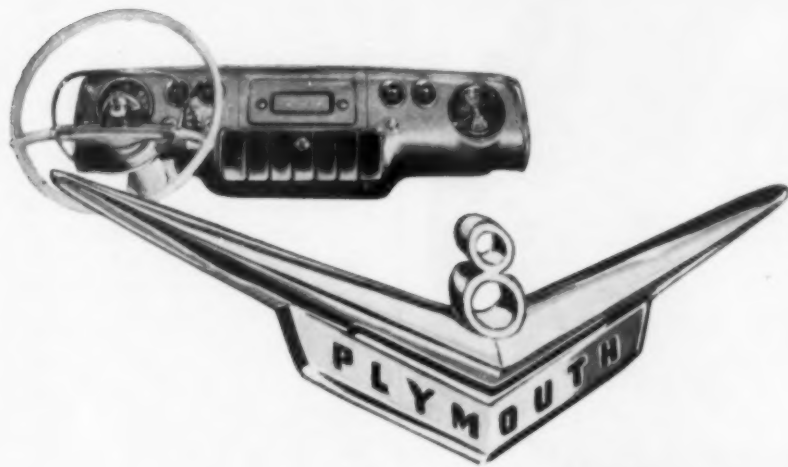
**Richard L. Ahearn**, formerly with Aro, Inc., Tullahoma, Tenn., has joined the Lockheed Aircraft Corp., Marietta, Ga., as a materials and process engineer in the production engineering department.

**M. D. E. Robinson** has been appointed manager, engineering service, western district, for Linde Air Products Co., division of Union Carbide of Canada, Ltd., Vancouver, B. C. **P. R. Maitland** has been named assistant district manager, western district, and has been transferred to Edmonton, Alta.

**Andrew R. Walsh**, formerly senior forge shop metallurgist with the Wyman-Gordon Co., Worcester, Mass., is now metallurgist, high-temperature alloys, with the Vacuum Metals Corp., Syracuse, N.Y.

**Eldred Bogart** has resigned as metallurgist at the Consolidated Vultee Aircraft Corp., Fort Worth, Tex., and is now a metallurgical laboratory engineer at Caterpillar Tractor Co., Peoria, Ill.

*knobs and nameplates help sell cars . . .*

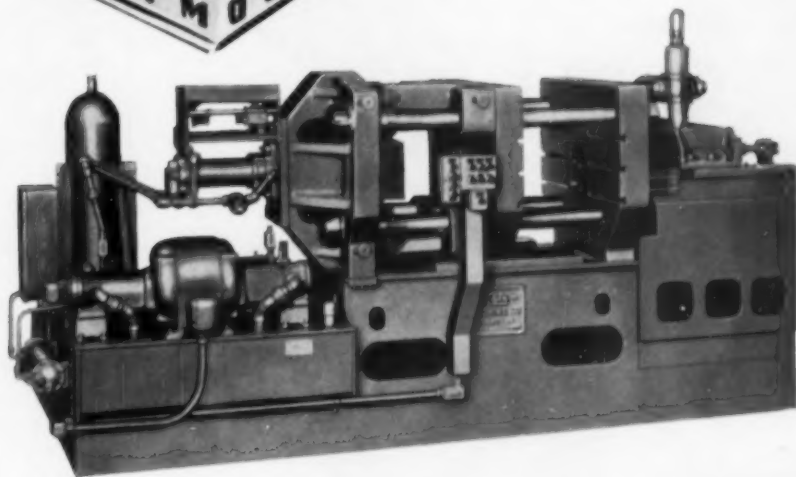


so

**CHRYSLER**

*suppliers*

*chose*



## **KUX** DIE CASTING MACHINES

*to get hardware finish quality castings*

Big Chrysler Corporation contracts for die-cast trim parts are held by the Trilex Corporation of Wayne, Michigan, and Ajax Manufacturing Corporation of Detroit.

"The primary concern of the Chrysler Corporation is quality," says Mr. John Airey of Trilex. "That's why we chose KUX machines; we know they produce hardware finish quality parts."

"But Chrysler considers price as well as quality," said Mr. Milton K. Pitts of Ajax. "We choose KUX because they put us in a better position to compete on a cost-per-unit basis."

Whether your main concern is lower production costs, quality, or both, investigate the advantages of KUX machines. Quality die castings economically produced often make a tremendous difference in price and salability. KUX, first name in die casting machines, can help make that difference for you! Write for our NEW illustrated catalog.

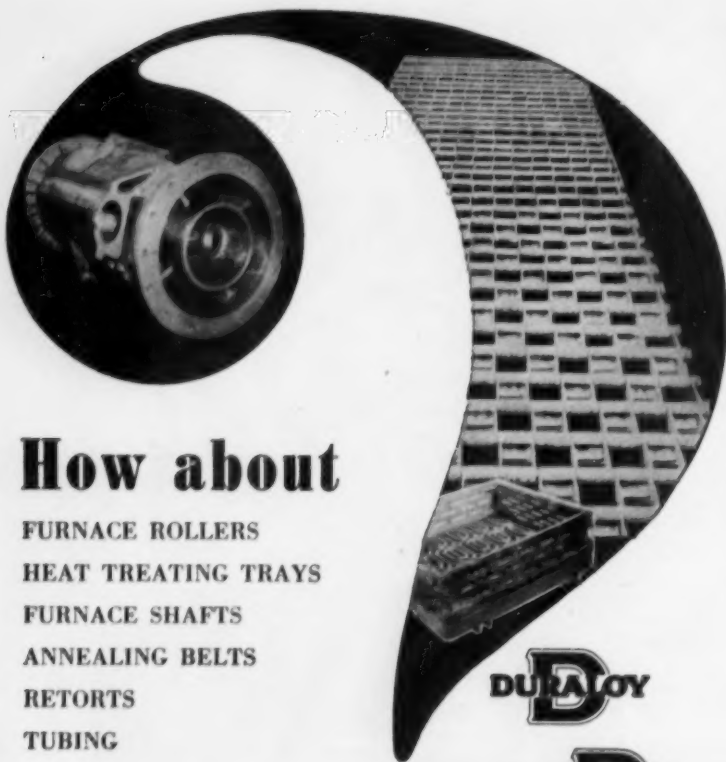
### MODEL BH-30 ILLUSTRATED

Hydraulically operated goose neck plunger type die casting machine for production of zinc, lead or tin castings.

**KUX** MACHINE CO. 6725 NORTH RIDGE AVENUE • CHICAGO 26, ILLINOIS

JUNE 1956

115



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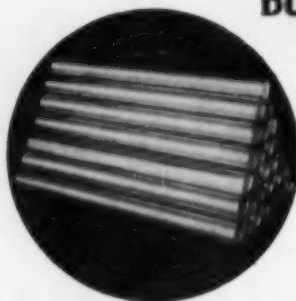
RETORTS

TUBING

Which are  
Heat Resistant

Corrosion Resistant

Abrasion Resistant



When ready to order, how about checking with us here at DURALOY? For more than thirty years we have specialized in high-alloy castings. In fact, we were among the first to produce static castings and the first to produce centrifugal castings. We are old hands at producing castings alloyed to fit each specific requirement and to finish them to any extent desired.

Melt, castings and finishing are carefully controlled and quality tested by our staff of metallurgists, chemists, X-ray and gamma ray technicians. If you would like more preliminary information, send for Bulletin No. 3150-G.

## THE DURALOY COMPANY

OFFICE AND PLANT: Scottsdale, Pa.  
EASTERN OFFICE: 12 East 41st Street, New York 17, N.Y.  
DETROIT OFFICE: 2398 Woodward Avenue, Pleasant Ridge, Mich.  
CHICAGO OFFICE: 112 South Michigan Avenue

## Personals . . .

**Kenneth M. Gleszer** recently was appointed executive vice-president of Dixon Sintaloy, Inc., Stamford, Conn., a subsidiary of the Joseph Dixon Crucible Co. Mr. Gleszer joined the company in 1952 as general manager of the powder metal division, and prior to that time was a consulting metallurgist in the field of powder metallurgy. **Anthony J. Zino**, formerly sales manager for Dixon Sintaloy, was named vice-president in charge of sales. Mr. Zino joined the parent company in 1951 as general sales manager and was transferred to the Stamford division two years later.

**F. M. Thomas** is now manager of equipment development at the electronics division of Sylvania Electric Products, Inc., Woburn, Mass. Previous to this, Mr. Thomas was manager of equipment engineering at Sylvania's atomic energy division, Hicksville, N. Y.

**J. Gordon Parr** has left the department of mining and metallurgy at the University of British Columbia to become associate professor of metallurgy in the department of mining and metallurgy, University of Alberta, Edmonton.

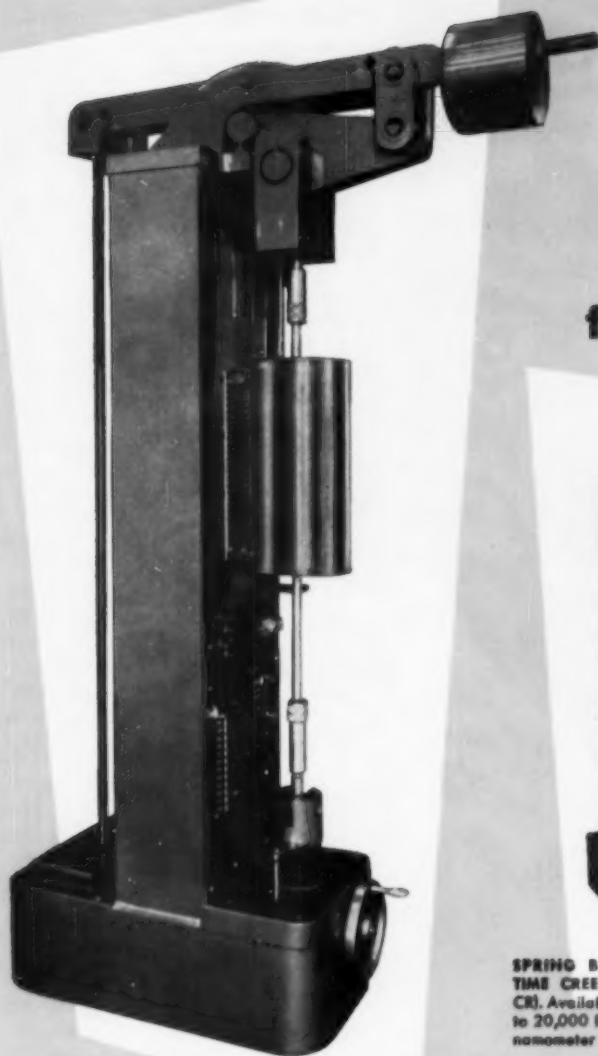
**Harry W. Robert, Jr.**, formerly materials engineer at the aero division of Minneapolis-Honeywell Regulator Co., is now a metallurgist with Contour Saws, Inc., Des Plaines, Ill.

**Edward F. O'Mara** is now a metallographer in the metals division of the Utica Drop Forge and Tool Corp., Utica, N. Y.

**Edward P. Rowady**, recently discharged from the Army, has accepted the position of project metallurgist with Eaton Mfg. Co., Detroit.

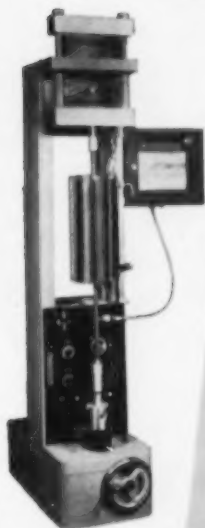
**Julius M. Simmons** is now employed in the nuclear engineering division of Ebasco Services, Inc., New York. Prior to his present position, Mr. Simmons was assistant director of metallurgy at the Argonne National Laboratory, Lemont, Ill.

**James O. McCaldin**, formerly senior engineer on the research staff of General Motors Corp., Detroit, is now research engineer at the semiconductor division of Hughes Aircraft Co., Los Angeles.

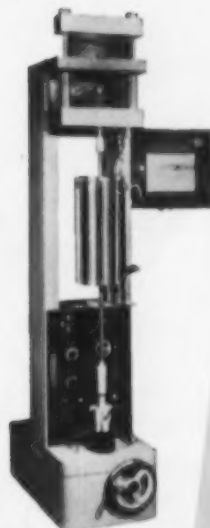


# 3 NEW MACHINES

for better creep testing



**SPRING BLOCK TYPE FOR SHORT TIME CREEP RUPTURE TESTS.** (Model CR). Available in 5 capacities, from 1,000 to 20,000 lbs. Load applied through dynamometer by motor-driven screw jack.



**SPRING BLOCK TYPE MACHINE FOR AUTOMATIC CREEP RELAXATION TESTS.** Model CX-04 (4,000 lbs. capacity).

**LEVER TYPE FOR LONG-TIME CREEP TESTS.** Model CL-20 (20,000 lbs. capacity). Load applied by dead weights. Lever ratio of 40 to 1 means less lifting for operator. Automatic take-up keeps lever arm horizontal as specimen elongates. Specimen fracture produces minimum shock since weights are maintained a fraction of an inch above base. Accuracy within  $\frac{1}{2}\%$  of load or 0.1% of capacity.

Only from Baldwin can you get exactly the right machine for each type of creep test. All three Baldwins are built on the same basic frame, so you can "convert" your machine by changing the head and accessories. Every Baldwin creep testing machine has these advantages:

- It's compact. Requires less floor space than any other creep machine.
- All instrumentation is readable from front of machine.
- Recorder can be mounted on machine or on centralized panel board.
- Improved furnace provides more even heat distribution. Overload protection prevents burn-out.

- Spherically seated pull rods assure axial loading.
- When specimen fails, shock to adjacent machines is minimized by new shock-absorbing base.
- Machine requires no special foundation, and need not be bolted to the floor.
- Performance-proven electric contact type extensometer gives best zero stability and widest range of magnifications.

A new bulletin on Baldwin Creep Testing Machines is just off the press. Write Dept. 1524, Electronics & Instrumentation Division, BLH Corporation, 806 Massachusetts Avenue, Cambridge, Mass.



## ELECTRONICS & INSTRUMENTATION DIVISION BALDWIN-LIMA-HAMILTON

DIVISIONS: Austin-Western • Eddystone • Hamilton • Lima •  
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# FINEST

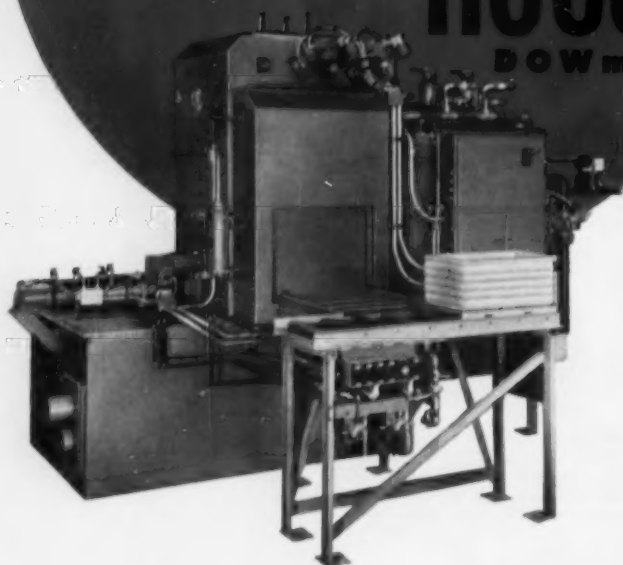
## AUTOMATED BATCH-TYPE

### CONTROLLED ATMOSPHERE

### FURNACE - THE

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DOWmatic



All the proven advantages of DOW'S top quality controlled atmosphere, furnaces with built-in atmosphere generators . . . PLUS time saving automation in one compact, efficient package.

This new furnace pre-conditions, loads and unloads the work chamber, quenches the charge and discharges the finished work without operator handling.

No time loss, no guessing, no human error . . . every load identically processed and handled.

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*First* WITH  
MECHANIZED, BATCH-  
TYPE, CONTROLLED  
ATMOSPHERE FURNACES

## Personals . . .

George H. Thurston ☉ has been appointed to represent the Duraloy Co., Scottsdale, Pa., in sales and service for all California north of Los Angeles. Mr. Thurston is a consulting metallurgist and manufacturers' representative on the West Coast.

Colin G. Walcott ☉ has been named carbide service engineer in the Detroit district of Firth Sterling Inc., Pittsburgh. Prior to this position, Mr. Walcott was associated with the Buick Motor Div., General Motors Corp., Detroit, as supervisor of research and development in the metallurgical department.

Van S. Wielosinski ☉ has resigned as director of metallurgy and assistant chief inspector of Willys Motors, Inc., Toledo, Ohio, to become chief metallurgist at New Process Gear Corp., Syracuse, N. Y. Mr. Wielosinski had been with Willys since 1942, and prior to that was associated with Carnegie-Illinois Steel Corp.

John D. Wood ☉, formerly serving in the U.S. Air Force in the materials laboratory at Wright Air Development Center, is now a metallurgist in the extrusion plant of the Kaiser Aluminum & Chemical Corp., Halethorpe, Md.

Louis H. Winkler ☉ was presented with a Missouri Honor Award for Distinguished Service in Engineering by the University of Missouri during the recent celebration of the centennial of the college of engineering of the University. A graduate of Missouri, Mr. Winkler has been metallurgical engineer at the Bethlehem Steel Co., Bethlehem, Pa. for nearly 30 years.

Carl Frederick Floe ☉ has been elected a director of Walworth Co., New York. Dr. Floe is a professor of metallurgy and assistant provost at Massachusetts Institute of Technology, and is a consultant on service behavior of metals and surface hardening of steel.

James Freese ☉ has been named general production manager of all plants of the Timken Roller Bearing Co. Joining the company in 1929, Mr. Freese was assistant general production manager until his recent appointment.



## GRANODIZE WITH GRANODINE® FOR THE FINISH THAT LASTS

The sparkling and durable paint finishes needed for white goods require a suitably prepared base. Granodizing with Granodine produces such a base on steel. It converts metallic surfaces to a nonmetallic coating of the proper texture for inhibiting corrosion and greatly increasing the adhesion and durability of the paint finish.

Investigate Granodizing with Granodine for your products. Write us for complete information.

**AMERICAN CHEMICAL PAINT COMPANY, Ambler 16, Pa.**  
DETROIT, MICH. • ST. JOSEPH, MO. • NILES, CALIF. • WINDSOR, ONT.



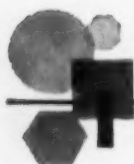


A call to any one of our seven warehouses will get you speedy service on your order... whether it's for *alloy steel bars, billets or forgings*, in any size, shape or treatment you need.

All seven warehouses are located in principal industrial areas. Each is modern and well-stocked, and staffed by expert metallurgists.

Call now if you need our own HY-TENsteels — "the standard steels of tomorrow", or standard AISI or SAE grades.

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In Canada: Sanderion-Newbould, Ltd., Montreal and Toronto

**WHEELOCK, LOVEJOY & COMPANY, INC.**

134 Sidney Street, Cambridge 39, Massachusetts

## Personals . . .

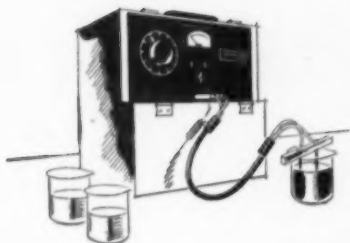
**James H. Keeler** ☼ recently was named as a liaison scientist in the metallurgy and ceramics department of the General Electric Research Laboratory, Schenectady, N. Y. A member of the research staff since 1951, Dr. Keeler will be responsible for maintaining the flow of information between the research departments of the Laboratory and operating components of the General Electric Co.

**Ralph J. Kotfila** ☼, sales engineer for Rem-Cru Titanium, Inc., Midland, Pa., has been named to represent the company in its new Chicago office. Mr. Kotfila joined Rem-Cru in 1954, after completing a tour of active duty with the U. S. Air Force. During his Air Force service, he was stationed at Wright Aeronautical Development Center in the materials laboratory.

**George A. Roberts** ☼, vice president of technology of the Vanadium-Alloys Steel Co., Latrobe, Pa., has been elected to the board of directors of the company. Associated with Vanadium-Alloys since 1941, Dr. Roberts is also a director of Vanadium-Alloys Steel of Canada, Ltd. He was president of the American Society for Metals during 1954-55 and is currently head of the ☼ Foundation for Education and Research.

**Albert B. Gagnebin** ☼ has been appointed manager of the nickel sales department of the International Nickel Co., Inc., New York. Associated with the company since 1930, Mr. Gagnebin was assistant manager in the department prior to his recent appointment. Before joining the nickel sales department, he was in charge of the ductile iron section of the development and research division of Inco. **Harold Larsen** ☼ has been appointed assistant manager of the nickel sales department, filling the vacancy left by Mr. Gagnebin. A member of the department for 30 years, Mr. Larsen last held the position of assistant to the manager.

**Rudolph Spacek** ☼ is now a tin mill metallurgist for Youngstown Sheet & Tube Co., East Chicago, Ind. Mr. Spacek was formerly with the American Can Co.



**"Quenchol Demonstrator showed...*They needed More Cooling Power to stop spotty hardness!*"**

A large manufacturer of locking pins recently had a problem getting uniform high hardness on SAE 1074 steel. Hardnesses varied from 34 to 61 R<sub>c</sub> Hardness. Since this and other factors pointed to the competitive oil they were using, they asked Sinclair Representative Russell Smith for his evaluation. Mr. Smith reports:

"Spotty hardness indicated that the oil being used lacked cooling power. A comparison test on the Sinclair Quenchol Demonstrator showed that this oil had a cooling power rating of 784... as compared with a rating of 1225 for QUENCHOL 521!"

### **This test convinced them!**

Mr. Smith continues, "The Quenchol Demonstrator test results persuaded this manufacturer to install QUENCHOL 521 immediately. Now they are getting an increased and uniform hardness range of 59 to 65 R<sub>c</sub> Hardness. Moreover, with QUENCHOL 521 *working loads have been increased 67%*, from 3 tons to 5 tons per quench, using the identical equipment and procedures! Needless to say, this manufacturer is very pleased with the cooling power and performance of QUENCHOL!"

Try a FREE Quenchol Demonstrator test on *your* present quenching oil. See how it compares with the amazing cooling power of QUENCHOL 521. Make arrangements through your local Sinclair Representative, or write to Sinclair Refining Company, Technical Service Division, 600 Fifth Avenue, New York 20, N. Y. Free literature is available, and there is no obligation.

# **SINCLAIR**

## **METAL WORKING OILS**

# Advances in Applied Radiation

DEVELOPMENTS in APPLIED RADIATION ENERGY, its APPLICATIONS and the APPARATUS USED TO PRODUCE IT

**16 to 1**  
**THICKNESS RANGE**  
**X-RAYED IN A**  
**SINGLE**  
**SHOT**



**Speeding production radiography** of small castings having high nickel or cobalt content, the x-rays from a one-million-volt Van de Graaff permit clear observation of details in 1/32" and 3/8" thicknesses in the same exposure. Heretofore, inspection of such castings has required two x-ray units having different penetration characteristics so that



Typical precision castings whose inspection is speeded by million-volt Van de Graaff radiography.

each might be used for a specific region of the casting. But the balance of low- and high-energy components, inherent in the Van de Graaff constant-potential x-ray beam, makes possible a

simplified, economical technique. Moreover, the radiographs obtainable with the Van de Graaff are easier to interpret than those made with lower-voltage x-rays because the large grain-size of the high-temperature alloys produces a diffraction pattern with lower-voltage x-rays.

Other examples of advantages gained with the Van de Graaff are given in our 24-page Bulletin R, which also gives full information on the equipment and its installation. Write today for your free copy.

## HIGH VOLTAGE ENGINEERING CORPORATION

7 UNIVERSITY ROAD

CAMBRIDGE 38, MASSACHUSETTS

## Personals . . .

**R. B. Rich** is now serving in the U.S. Army at Watertown Arsenal Ordnance Laboratory, Watertown, Mass. Prior to his induction, Pfc. Rich was employed by Revere Copper and Brass, Inc., Baltimore, Md.

**Robert C. Anderson**, formerly with the Nuclear Propulsion Dept., General Electric Co., Evendale, Ohio, has been appointed to the staff of the Y-12 Plant, Union Carbide Nuclear Co., Oak Ridge, Tenn.

**Robert G. Carlson** has been transferred from the research laboratory of General Electric Co., Schenectady, N.Y., to the refractory metals laboratory of the Lamp Wire and Phosphorus Dept. in Cleveland.

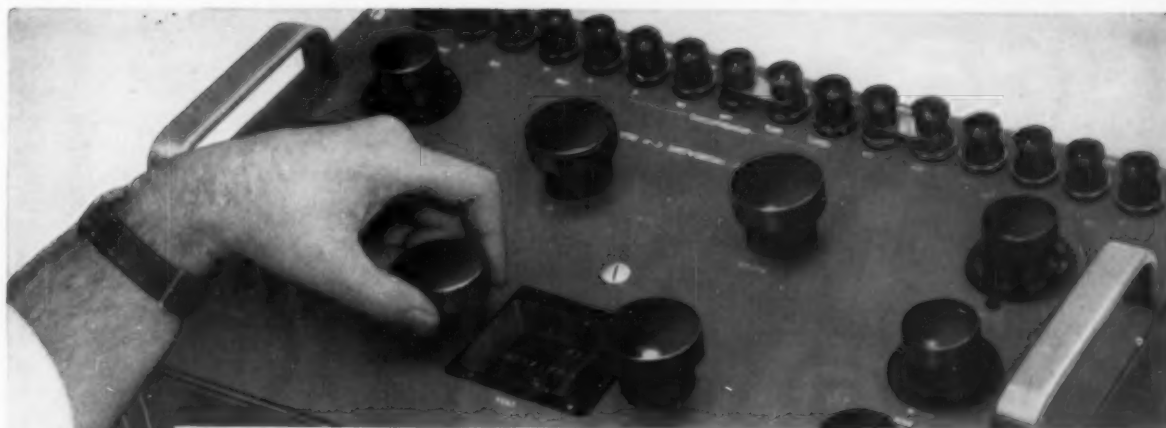
**C. Sheldon Roberts** has accepted a position as physical metallurgist for the Shockley Semiconductors Laboratory, Mountain View, Calif. Mr. Roberts formerly was group leader in plastic deformation research at the metallurgical laboratory of the Dow Chemical Co., Midland, Mich.

**John E. Srawley** has left the Arwood Precision Casting Corp. to become supervising metallurgist in the metallurgy division of the Naval Research Laboratory, Washington, D. C.

**Richard A. Dodd** has been appointed assistant professor of metallurgical engineering at the University of Pennsylvania. Dr. Dodd came to North America in 1954 as a research metallurgist with the Canadian Department of Mines and Technical Surveys. Prior to that time he was associated with universities in South Africa and England.

**Gordon T. Bedford** recently joined Rem-Cru Titanium, Inc., Midland, Pa., as a sales engineer. Mr. Bedford was formerly associated with the Rustless Iron and Steel Corp., and Armco Steel Corp.

**M. L. Backstrom** has been appointed assistant district sales manager for the Chicago district of Firth Sterling, Inc., Pittsburgh. Before joining Firth in 1948 as a carbide service engineer, Mr. Backstrom was associated with the Boss Engineering Co., Pittsburgh.



## **NEW! TYPE K-3 UNIVERSAL POTENTIOMETER**

**makes Precise Voltage Measurements  
easier than ever before**



- Scale reads directly in voltage
- Guarded against humidity, static, leakage of any kind
- "Thermal Free" circuit reduces voltage errors



unique instrument in hot, humid weather . . . in cold, dry weather . . . without worrying about leakage or static.

The many new design and construction features . . . metal case for electrostatic shielding . . . guarding of battery and detector circuits . . . enclosed switches and slidewires . . . thermal free circuit construction . . . central reading window . . . make this Type K-3 Universal (Guarded)

Potentiometer the most advanced general purpose instrument available today. You will find it a worthy new addition to the Type K line . . . originated some 50 years ago . . . the world's most widely used precision potentiometers.

Six pages of data are required to give you full details. Ask for Data Sheet E-51 (6); write your nearest L&N Office or 4927 Stenton Avenue, Philadelphia 44, Pa.

**LEEDS**  **NORTHROP**  
instruments automatic controls • furnaces

# CHRYSLER builds-in Quality



Figure 1 shows the microstructure of a steel after it has been quenched at 500° F. The same specimen is shown in Figure 2 after reheating for one hour at 800° F. An original automotive paint surface is shown in Figure 3; Figure 4 is the same surface after the binder has broken down and free pigment particles have appeared, forming a whitish surface layer.

In producing its great line of cars "with the forward look," the Chrysler Corporation uses the RCA Electron Microscope to inspect many of the materials. These studies cover steel, paint finishes, rubber parts, metal powders, brake linings, and the extremely fine colloidal particles used for reinforcing fillers in plastics and rubber.

The investigations, which are headed by Dr. D. M. Teague of the Chrysler Physical-Chemical Research Department, also have been broadened to include foundry smoke and the effect of wear upon metallic parts.



## RADIO CORPORATION of AMERICA



More and more the use of the RCA Electron Microscope is becoming mandatory throughout industry for the high magnification and resolution it affords. Find out how the Electron Microscope can help you . . . to determine the structure of materials, control quality, cut costs, save time, accelerate development work. Installation supervision is supplied and contract service by the RCA Service Company is available, if desired. For complete information, write to Dept. F-72, Building 15-1, Radio Corporation of America, Camden, N. J. In Canada: RCA VICTOR Company Ltd., Montreal.

## Personals . . .

Thomas D. Hayes ☉ has retired from the U. S. Steel Corp., Chicago, after 22 years of service. Before coming to U. S. Steel in 1934, Mr. Hayes was associated with the Republic Steel Corp., Timken Roller Bearing Co. and Dodge Bros. Corp.

Clo. E. Armantrout ☉ has transferred from the Bureau of Mines, Rolla, Mo., to the physical metallurgy branch of the Bureau in Albany, Ore. where he is in charge of fabrication and development work.

Lester C. Hill ☉, formerly assistant sales manager of Vulcan Crucible Steel Co., Div. of the H. K. Porter Co., Inc., Aliquippa, Pa., has been appointed general sales manager. Prior to joining Vulcan Crucible in 1953, Mr. Hill was a sales engineer with Crucible Steel Co. of America, Pittsburgh.

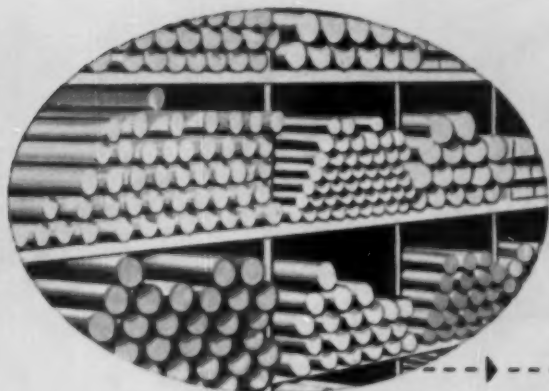
William E. Lind ☉ is now manager of the newly formed truck, bus and transportation refrigeration division of Frigikar Corp., Dallas, Tex. Mr. Lind was formerly vice president and general manager of ARA Automotive Air Conditioning Co., Fort Worth, Tex.

Thomas F. O'Brien ☉ recently was appointed sales engineer for the metals and fabrication division, Fansteel Metallurgical Corp., North Chicago, Ill. Mr. O'Brien's territory is in the east and his headquarters will be in Abington, Pa.

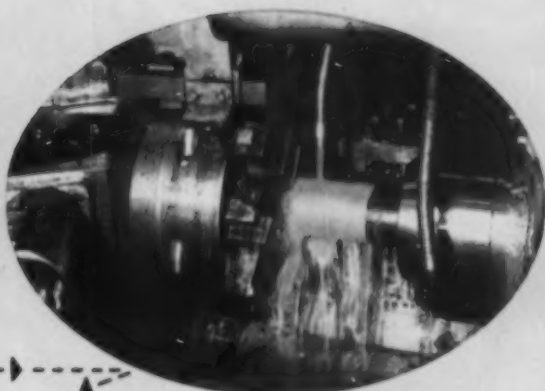
James F. Reid ☉ has been named assistant director and chief of the ferro-alloys section of the iron and steel division of the Business Defense and Service Administration, U. S. Department of Commerce. Mr. Reid recently retired from the Timken Roller Bearing Co., Canton, Ohio, after 37 years with the company. At his retirement, he held the post of general production manager.

Richard B. Connell ☉, a sales representative in the district sales office of the Sharon Steel Corp., Sharon, Pa., has been promoted to a new position in the customer service department.

R. E. Cutrell ☉ is now a metallurgical engineer at the Colorado Rocky Flats plant of the Dow Chemical Co.



piece of steel



machining operation



heat treating furnace



## The quench must be right, or the whole job is wrong

Ask any heat treater. When you come to the quench, you can't take chances. Expensive material, costly machining, painstaking heat treating can all be ruined if the quench goes wrong. All the work that went before depends upon this final step. If it "misses", the job is no good.

Top heat treaters don't risk costly processing on ordinary quenching oils. They know they can depend upon the uniformity, quenching speed and stability of Houghto-Quench. They know it's just common sense to use the best quenching oil you can get.

Houghto-Quench Oil gives you the fastest quench this side of water, and it's this speed that assures adequate hardness even for heavy sections and for steels in the low hardenability range. Its complete "wet-out" assures you there will be no soft spots and less carry off. Houghto-Quench increases heat treating effectiveness, with lower cost per ton of steel quenched.

Ask your Houghton Man to show you the superior performance of Houghto-Quench or write direct to E. F. Houghton & Co., 303 W. Lehigh Avenue, Philadelphia 33, Pa.

QUENCHING OILS...products of



Ready to give you  
on-the-job service . . .

# Stop Aluminum Corrosion!

# Insure Paint Adhesion

# Provide Ornamental Finish

## **TURCOAT 4178**

(Aluminum Surface Conversion Coating)



### **DOES ALL THREE!... Fixes Immediately, Too**

Here's a process that provides aluminum with an ornamental, paint-gripping, corrosion-resistant coating... and does it faster and better!

Turcoat 4178 works on the surface conversion principle... that is, the coating is partially derived from the metal itself. Thus, coating and metal are firmly interlocked... even in tiniest crevices. The coating is a light golden color that imparts a special beauty when used for decorative purposes.

One user reports that square footage processed has doubled since the installation of Turcoat 4178. Key to this speed is the manner in which the coating "sets" and becomes non-smearing immediately. Drying is unnecessary. Parts can be further processed without any delay in production! Moreover, the coating is uniform. There are no light, tell-tale untreated sections around welds, corners or holes.

The Turcoat 4178 Coating becomes non-smearing immediately upon withdrawal from processing. Drying is unnecessary. Parts can be handled freely while still wet without danger of smearing or streaking coating.



#### **MEETS GOVERNMENT SPECIFICATION**

Meets Government Specification MIL-C-5541.



#### **EASY TO CONTROL**

Simpler titrations... Great latitude in solution strength. Eliminates need for constant complicated control.



#### **EASY TO USE**

Apply by immersion, spray washer or hand methods. Gold color gives visual control over processing.



**TURCO PRODUCTS, INC.**  
Chemical Processing Compounds  
6135 So. Central Ave., Los Angeles 1, Calif.  
Factories: Newark, Chicago, Houston, Los Angeles  
Offices in all Principal Cities

Write for detailed technical literature.

Please affix coupon to company letterhead.  
**TURCO PRODUCTS, INC.**  
6135 S. Central Ave., Los Angeles 1, Calif.  
Please send me detailed technical information on Turcoat 4178.

NAME \_\_\_\_\_  
TITLE \_\_\_\_\_

Manufactured in Canada by B. W. Deane & Co., Montreal

## **Personals . . .**

D. E. Creek ☼ is now serving in the U. S. Navy aboard a Pearl Harbor-based destroyer.

Frank J. Worzala ☼, a recent recipient of a bachelor's degree in metallurgical engineering from the University of Wisconsin, is now on rotational training at the Hanford atomic products operations of the General Electric Co., in Richland, Wash.

John C. Bradley ☼ has retired after 48 years with the American Brass Co., Waterbury, Conn.

Elliott H. Hollenback ☼ has been appointed chief metallurgist at the Johnstown, Pa., plant, Bethlehem Steel Co. Mr. Hollenback succeeds R. E. Penrod ☼ who has retired after 53 years of service to Bethlehem and its predecessors.

James D. Van Kirk ☼, formerly laboratory manager at the Magnaflux Corp., St. Louis, Mo., has been appointed field engineer.

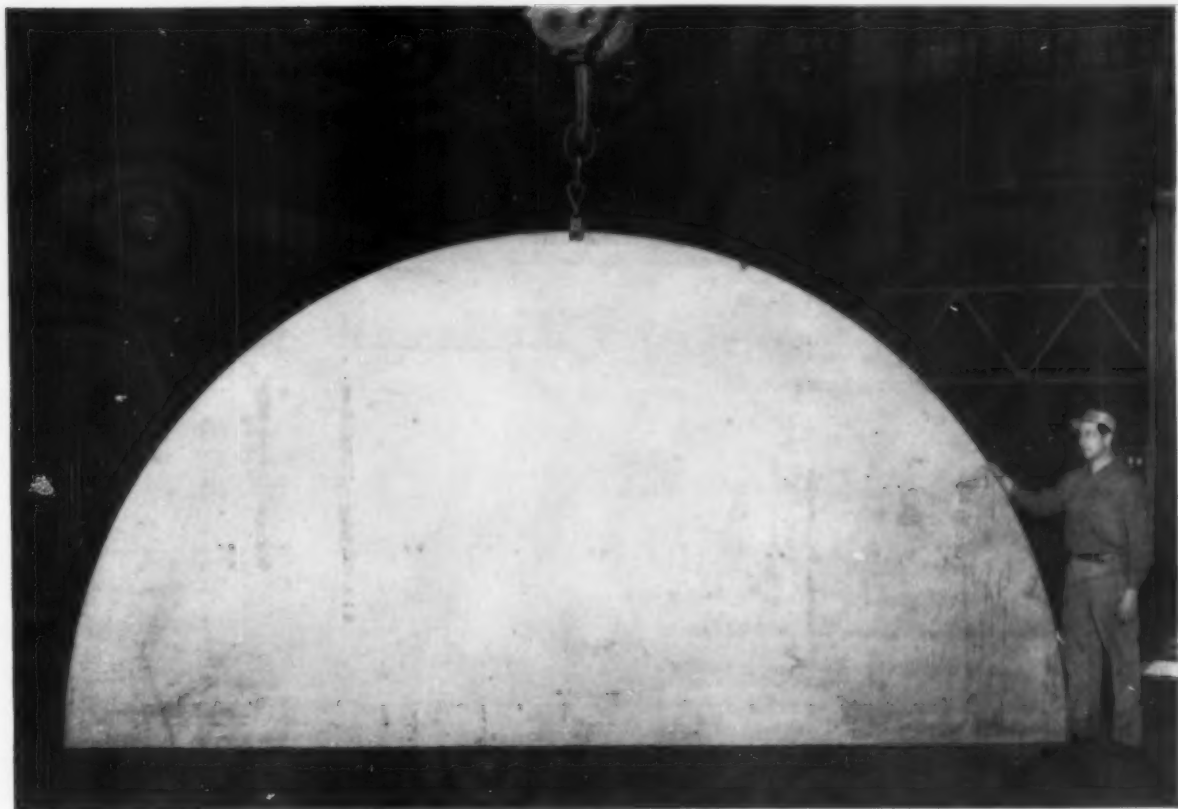
D. J. MacDonald ☼ has been named plant and production manager at Metals & Alloys, Ltd., Montreal, Que., Canada.

James A. McLaughlin ☼, a sales representative for E. F. Houghton & Co., Philadelphia, has been transferred from the Chicago territory to Minnesota. Mr. McLaughlin has been with the company since 1952.

George J. Mills ☼ has resigned as chief of research branch, metallurgy research laboratory, Frankford Arsenal, Philadelphia. Dr. Mills' new position is research specialist in the chemistry and physics section, Jet Propulsion Laboratory, Pasadena, Calif.

Ross Hershey ☼ has been promoted from sales engineer in the Detroit office of Timken Roller Bearing Co., to district sales manager of Timken's Buffalo district. Mr. Hershey joined the steel sales division of Timken in 1940.

M. H. Binstock ☼, formerly section head at the atomic energy division of Sylvania Electric Products, Inc., Bayside, N. Y., is now an engineer specialist at the atomics international division of North American Aviation, Canoga Park, Calif.



## Carlson specialized service keeps your costs low

Here's how Carlson specialized service in stainless plate worked on this job.

The illustration shows one of two segments of a tank head blank. Made of 1" thick, Type 302 stainless steel, the head blank measures 210" in diameter and weighs approximately 9000 pounds. Each segment was produced so accurately the customer did not have to "true up" the abrasive cut straight edges before welding the two segments together. This meant the customer had what he wanted, the way he wanted it—produced to his exact requirements.

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# Digests of Important Articles

## How Good Is Titanium?

Digest of "The Application of a New Structural Index to Compare Titanium Alloys With Other Materials in Airframe Structures", by L. R. Jackson and S. A. Gordon, Titanium Metallurgical Laboratory Report No. 24 (Dec. 1, 1955) to Office of the Assistant Secretary of Defense for Research and Development.

WHEN a new material is suggested for use in critical members of important machines or structures it must be appraised in terms of experience with the conventional materials in long and satisfactory use. When it comes to fuselages or large fuselage parts for ultrasonic aircraft operating at somewhat elevated temperatures, the problem becomes more difficult, because there is very little experience with such machines to draw upon. Prior to full-scale use the new material must of course first pass successfully the conventional acceptance tests for old-fashioned metals. Figure 1 shows how three titanium alloys compare at various temperatures on a strength-weight basis, with some aluminum alloys, high-strength steels and stainless steels. ("Strength", in this connection, means ultimate tensile strength tested at standard strain rates and other conditions.) It should be emphasized that this figure compares high-grade metal, and not joints working in tension, which in many instances leave much to be desired.

However, in an airframe far less than half the members carry tensile stress. The most critical members in complicated structures are columns or sections bearing compressive stresses. Evaluation and design have previously been based on formulas which predict the buckling stress in the respective elements of the section, whereas the crippling strength should be the real criterion. This

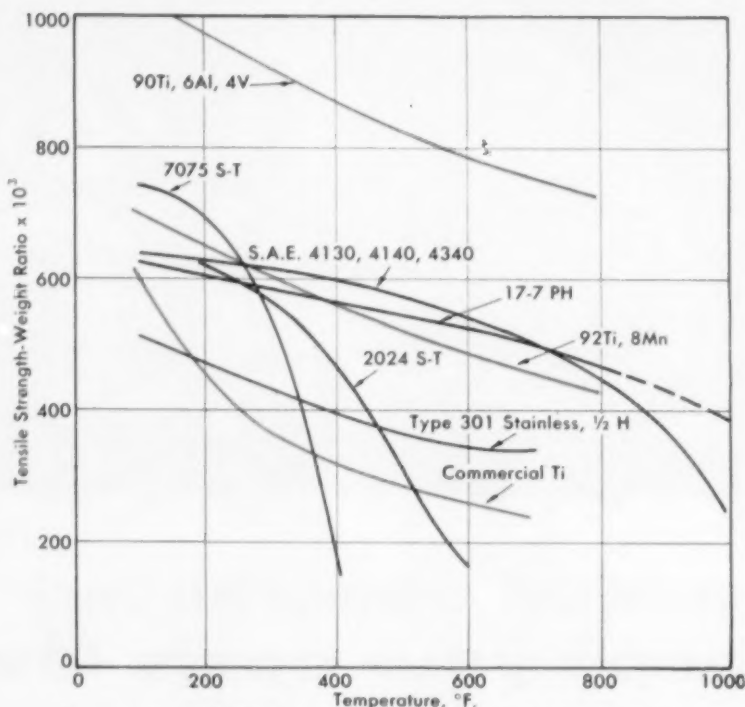


Fig. 1 — Strength-Weight Comparison of Several Metals at Various Temperatures for Tensile Members in Aircraft Construction. Ultimate tensile strengths at room temperatures are as follows:

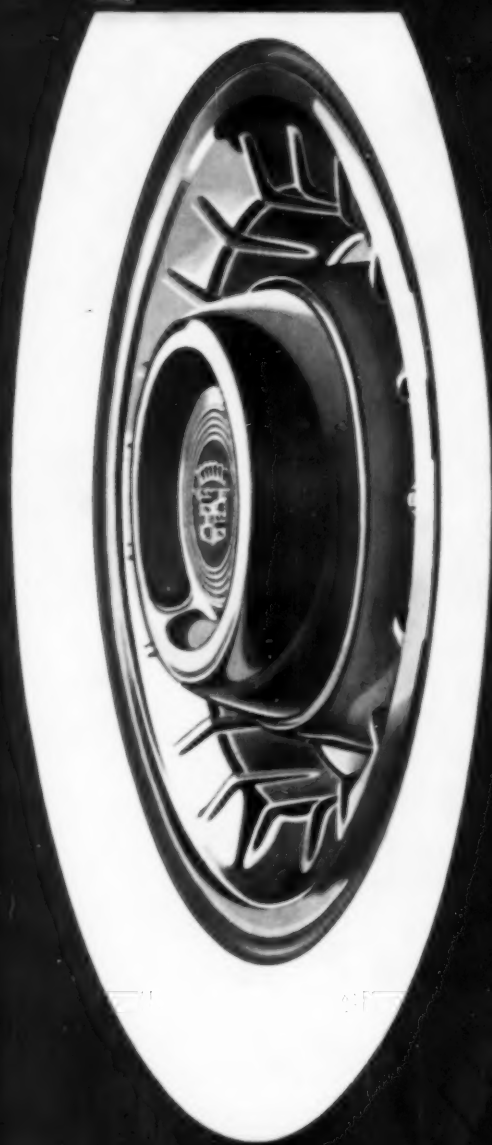
Aluminum 2024 S-T	64,000 psi.
7075 S-T	74,000
Stainless 301 (17-7)	155,000
17-7 PH	174,000
Alloy Steel 4130, 4140	188,000
4340	188,000
Titanium metal	100,000
92 Ti, 8 Mn	120,000
90 Ti, 6 Al, 4 V	180,000

concept was developed in a paper which R. A. Needham published on "The Ultimate Strength of Aluminum Alloy Structural Shapes in Compression" in the *Journal of Aeronautical Sciences* in April 1954, wherein he developed a formula applicable to "stiffeners" — the most important type of compression components in modern aircraft — relating the "Structural index" of a wide variety of useful forms bent from 2024-T 3 (24 S-T 3) aluminum alloy sheet to their crippling stress in compression, in turn computed from their dimensions and the yield stress of the material in compression (0.2% offset) and its elastic modulus.

When buckling stress is plotted against structural index for these

stiffeners on log-log coordinates they fall on a straight line. Later tests by G. L. Gallaher for the National Advisory Committee for Aeronautics (Document Tn No. 1718) on extruded Z-sections of strong aluminum alloys fell on the same curve.

Messrs. Jackson and Gordon believe that this method has a wide applicability in comparing materials of construction for compression members when they find that similar



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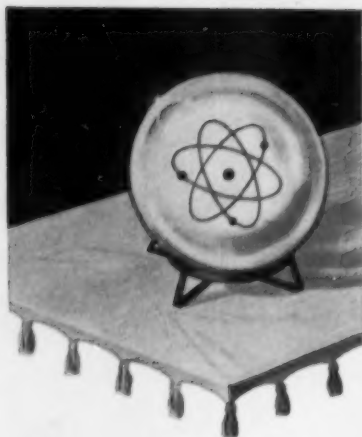


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## Titanium . . .

computations from tests at various temperatures on titanium alloy angles and stiffeners made by Convair in San Diego and Boeing in Seattle and plotted on log-log paper fall on straight lines of the same slope as the tests on standard aluminum alloys by Needham and Callaher. From such data they have constructed Fig. 2 and 3 showing the crippling-stress-weight ratio for 7075-T6 (75 S-T 6) aged 17-7 PH sheet, and

titanium alloy sheet and extrusions. Figure 2 is for a rather low structural index, whereas Fig. 3 is for "the highest practical value of structural index".

The authors conclude: "On both of these comparisons all of the titanium alloys illustrated have areas of usefulness. Furthermore, if material having the properties illustrated by the particular heat of 90 Ti, 6 Al, 4 V alloy becomes generally available, a definite superiority is indicated at low structural indices. At the highest practical value of struc-

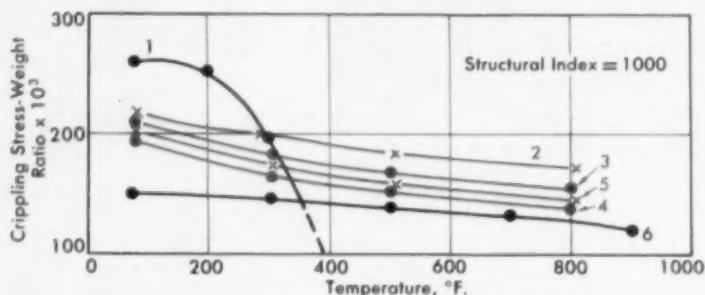


Fig. 2 - Crippling Stress-Density Ratios at Various Temperatures for Stiffeners in Aircraft Construction

- 1 - 7075-T 6 (75 S-T 6) Alclad sheet aged
- 2 - 90 Ti, 6 Al, 4 V extrusion
- 3 - C-110 M Ti alloy sheet, Heats 30 and 31
- 4 - C-110 M Ti alloy sheet, Heat 20
- 5 - RC-130 B Ti alloy extrusion
- 6 - 17-7 PH (17 Ni, 7 Cr, precipitation hardened stainless sheet)

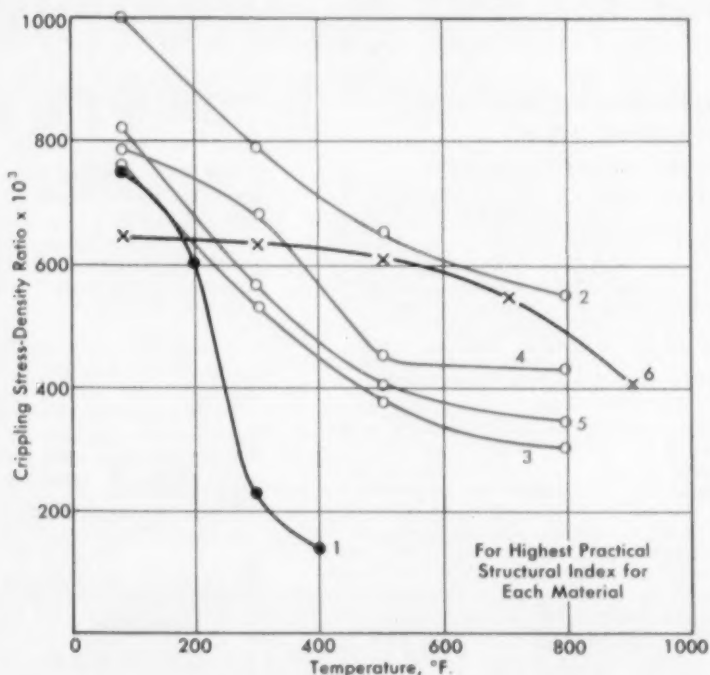


Fig. 3 - Crippling Stress-Density Ratios for Stiffeners Designed at Highest Practical Structural Index

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## Titanium . . .

tural index the current available titanium alloys do not have such outstanding properties, but the 6 Al, 4 V alloy still has definite superiority. Before this superiority can be realized, at least two major hurdles must be overcome:

"First, it will be necessary to develop means of producing alloys having properties equivalent to those in this heat in sheet form as well as in

extruded shapes, and they must be capable of some fabrication.

"The second hurdle arises from the fact that it is not easy to design or build airframe components having such high structural indices. It is entirely possible that to use the full capability of materials, some sort of sandwich construction will be involved. So far no practical method has been found to make large shapes of sandwich construction of a type that can operate at elevated temperatures."

E. E. T.

## Applications of Investment Castings

Digest of five papers presented at the Investment Casting Conference of the Albuquerque Chapter of the American Society for Metals in April 1955.

ALTHOUGH the investment casting process has been used for centuries to make small intricate parts, it was not adapted successfully to mass production until World War II when forging capacity was not sufficient to meet the demand for turbine buckets for turbosuperchargers. Once the change from forgings to investment castings was made, production increased tremendously and one foundry alone cast over 2,000,000 pieces in a single month. This increase in volume enabled foundries to invest in more experimentation so that costs have been reduced enough to make investment castings competitive in many commercial applications to forgings, stampings, weldments and machined parts. The current state of the art was the subject of the recent symposium conducted by the Albuquerque Chapter of the American Society for Metals.

### Improvements and Economics

In the first of five papers presented, C. G. Chisholm, Haynes Steelite Co., discussed "The Investment Casting Process and Its Field of Application". Many improvements have been made during the last 15 years in equipment, materials and techniques but the essential steps in the process are unchanged. A split die is made with an internal cavity whose shape and dimensions are the same as those of the casting required with allowance for shrink and other processing variables. Patterns are made with this die from wax, plastic or frozen mercury; if small, they are assembled with gates and risers into a cluster. If the casting is large, gates and riser patterns may be added after the pattern is removed from the die or may be built into the die.

The cluster is dipped and sometimes sprayed with a fine refractory suspension and then placed in a flask which is subsequently filled with the investment material, usually silica and ethyl silicate. The investment hardens by chemical action and the



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## Boron and Its Effects in Alloy Steels

Boron is a nonmetallic element of which this country has a plentiful supply. In its natural or unprocessed state it occurs only in combination, as in borax, etc. Pure boron is a gray, extremely hard solid with a melting point in excess of 4000 deg F.

This element is used in steel for one purpose only—to increase hardenability; that is, to increase the depth to which the steel will harden when quenched. Its effective use is limited to sections whose size and shape permit of liquid quenching. Only a few thousandths of 1 pct is ordinarily added, and boron steels are evaluated by increased hardenability rather than chemical content. A number of alloys, including several grades of ferroboration, are available for adding boron to steel.

Boron intensifies the hardenability characteristics of other elements present in the steel. It makes possible a considerable degree of alloy conservation when used with steels containing small amounts of alloying elements. However, since it readily oxidizes at high temperatures, some steelmakers prefer a melt with relatively low boron content and relatively high contents of other elements that protect the boron from oxidation.

It should be noted that boron is very effective when used with low-carbon alloy steels; but its effect is reduced as the carbon increases. When the carbon content is above

0.60 pct, the use of boron is not suggested, the exception being the "case" in those steels that are carburized.

Boron steels often require closer temperature control in heat-treatment than do some of the other alloy analyses; but aside from this they present no special problems. Their cold- and hot-working properties are considered at least equal to those of ordinary alloy steels. In cases where boron makes possible a lower alloy content, improved machinability frequently results.

If you would like to know more about boron and its effects in alloy steels, you are invited to consult with Bethlehem's metallurgical staff. Our technicians will gladly give you all the information you need, and will work closely with you in every respect. And when it is time to replenish supplies of steel, remember that Bethlehem manufactures the full range of AISI standard alloy grades, as well as special-analysis steels and all carbon grades.

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## Investment Castings . . .

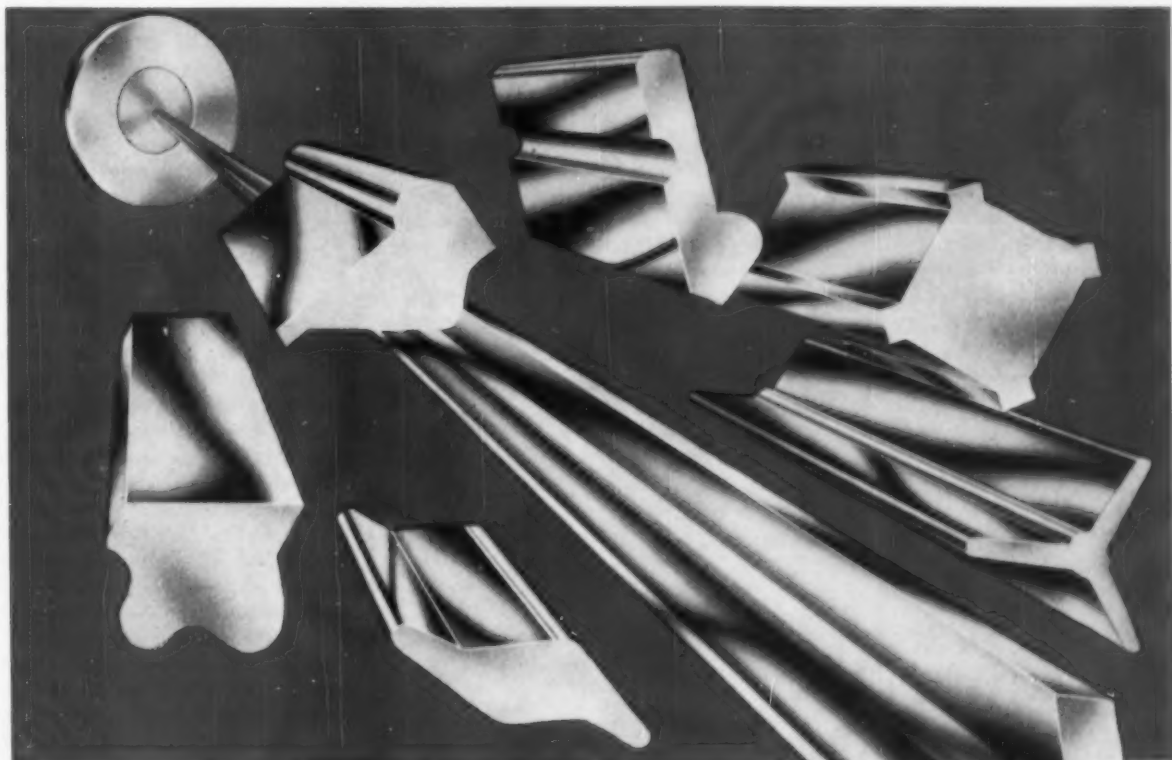
assembly is charged in a furnace where the pattern material is melted or burned out and the emptied mold preheated for the casting. Careful control of the temperature of both mold and metal is necessary in order to get the best dimensional accuracy and mechanical properties.

Factors which determine whether investment casting is the most economical method of producing a part include the over-all size and dimensional tolerances, surface finish requirements, properties of the metal and the shape, particularly at the edges. One of the most important reasons that investment casting is used for turbine buckets is the need for thin trailing edges which can only be obtained in castings by pouring in a hot mold. Another advantage of investment casting for this application is that parting is not necessary whereas it is required in other casting methods. The design is such that dimensional tolerances could not be met in critical areas because of parting line variation.

Mr. Chisholm showed a number of other components where investment castings have replaced forgings, machined parts and weldments. One large field of usefulness is in production of small orders of parts for development purposes that may subsequently be produced by shell molding, sand casting, powder metallurgy or die casting. The tooling for investment casting is so often more economical than that for forging, stamping or screw machining that this process is most effective for development work.

### Design Factors

A detailed analysis of other reasons for using investment castings was presented in "Design Factors Applicable to Precision Casting" by J. B. Price, Arwood Precision Casting Corp. In his introduction he denounced the practice formerly used by a few foundries of making ridiculous promises about the precision obtainable with this process. Investment casting is a precise method compared to other foundry techniques but is not precise as a toolmaker or machinist measures precision. For steel castings dimensional tolerances can be held to within 0.005 in. per in. with a minimum of



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## Investment Castings . . .

0.003 in. per in. That means that on a dimension of 0.6 in. or less, the tolerance is 0.003 in. per in. With dimensions over 6 in. the dimensional tolerance is not much better than that which can be obtained by good sand casting. For lower melting alloys, accuracy may be increased by 20 to 40%.

Surface finish is another property

of investment casting for which extravagant claims have occasionally been made. For steel, 100 micro-in. is the usual value although foundries prefer a specification of 125. For some castings, 80  $\mu$ -in. is possible. Secondary polishing operations are required for better finishes.

Minimum wall thickness should be about 0.050 in., although for small areas, walls as thin as 0.030 in. may be cast. Large flat areas are difficult to cast because in such areas the

dip coat tends to buckle away from the investment. The thickness of edges like the trailing edge of a turbine blade should be at least 0.012 to 0.015 in. Threads can be cast if the fit is not critical. If the die is split through the thread, there will be an indication of the parting line which must be chased.

### Castability

Although practically any metal can be cast, the yield of usable castings varies considerably. The effects of the various factors that influence castability were outlined in "Investment Casting Alloys" by W. A. Dubovick of Engineered Precision Casting Co.

The ideal casting material would have all the following characteristics: good fluidity, low melting point, wide solidification range, no gas absorption, no detrimental surface decarburization, no hot shortness, good chemical reproducibility and good as-cast surface finish. Metals that lack one or more of these desirable properties may also be cast but often it will be necessary to search for specialized foundries willing to accept orders for castings made from a difficult-to-cast alloy.

Fluidity is extremely important for castings with thin sections, fine edges and sharp details. Fortunately, with the investment casting process, the flow of metal can be improved by increasing the temperature of mold so that the molten metal remains hot longer. Pressure, centrifugal and suction casting can also be used to help the flow of metal.

If two or more alloys would be satisfactory for the service requirements for a specific casting, the alloy with the lowest melting point will usually make the best castings. With a lower melting point alloy there is less chance of eroding, or washing, of the investment material or of defects due to volatilization of carbonaceous residue from the pattern material.

A wide solidification temperature range means that the casting can be fed for a longer period of time and there will be less likelihood of shrinkage porosity. Another kind of defect called gas porosity is due to too great a difference in solubility of gas between the molten and liquid states. The excess gas dissolved in the liquid metal is evolved and forms pores in the casting. This de-

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fect is very pronounced in some aluminum and copper alloys.

Fracture or tearing of a metal during solidification is called hot shortness. In steels, it is usually caused by excess sulphur which forms a weak grain-boundary eutectic that may crack under the stress of shrinkage. It is prevalent in high-nickel alloys and they are very difficult to cast when heavy sections are connected to thin ones.

Chemical reproducibility is affected most by the rate of oxidation or volatilization of the individual alloying elements. There is usually no loss during melting of such elements as nickel, molybdenum, tungsten and copper but there may be as much as 80% loss of titanium additions and 50% of vanadium and columbium. Changes in composition can also be caused by pickup of impurities or unwanted additions. For example, alloys melted in carbon-arc furnaces can pick up carbon faster than it is lost through oxidation and a very low limit on carbon content cannot be met with such furnaces.


Poor surface finish can usually be attributed to some property of the metal like a high melting point. The exceptions are those alloys which form oxides that have slagging reactions with the investment. Manganese, for example, will react with silica in the investment to form a low-melting slag at the surface of the casting and cause slag pockets. Aluminum alloys, some of the copper-base alloys, cast iron, the 300 series stainless steels and cobalt-base alloys usually have good as-cast surface finishes.

Many of the difficulties associated with investment casting could be minimized if the foundry were allowed a wider range of chemical composition. Unfortunately specifications are too often based on the equivalent wrought alloys without regard to the differences between casting and rolling. The performance of a specific casting may be influenced much more by foundry variables than by slight changes in composition and often major composition changes are necessary to obtain service in a cast part equivalent to one fabricated from wrought material. Whenever possible, standard specifications for casting alloys should be used. The Investment Casting Institute is now preparing

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A screw manufacturer. Operating temperature, 1550° to 1600°, 16 hours per day. Idling temperature, 1350° to 1400°, 8 hours per day. NEU-POT service, 5616 hours . . . cost, less than 6¢ per hour.

A heat treating and brazing shop. Operating temperature, 1500° to 1550°. NEU-POT service, 3300 hours with "no end in sight." Cost to date, 13¢ per hour.

A stamping manufacturer. Previous average life of pots, 165 hours at a cost of over 54¢ per hour. NEU-POT life on same job, already over 1000 hours at average hourly cost of 34½¢.

There are, of course, some very good reasons for such success with NEU-POTS. Rolock methods and skills in welded fabrication of high heat-resistant alloys develop the full advantages of this type of construction, while solving previous tough problems such as joint leakage. Special X-ray inspection procedures on each individual pot before shipment furnish a positive extra safeguard.

Because some neutral salt pot users are hard to convince . . . till they make their own tests . . . we give special attention to first orders. Why not send yours in today?

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Easier Operation, Lower Cost

2RL56



# Lepel

## HIGH FREQUENCY Induction HEATING UNITS

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HARDENING  
BOMBARDING  
SOLDERING  
ANNEALING  
MELTING

The Lepel line of induction heating units represents the most advanced thought in the field of electronics as well as the most practical and efficient source of heat yet developed for industrial heating. With a background of half a century of electrical and metallurgical experience, the name Lepel has become the symbol for quality in induction heating equipment embodying the highest standards of engineering achievement, dependable low cost operation and safety.

If you are interested in the application of induction heating you are invited to send samples of the work with specifications of the operations to be performed. Our engineers will process these samples and return the completed job with full data and recommendations without any cost or obligation.

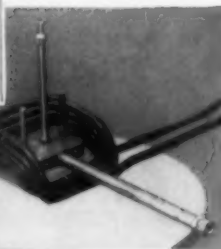
### TYPICAL INDUCTION HEATING APPLICATIONS



The simultaneous soldering of a group of components within one load coil is an ideal application for induction heating. The assemblies consist of mounting studs and tubes inserted into a machined part together with preformed solder rings. The heating is done so rapidly that there is practically no scaling or discoloration.



A Lepel installation at Federal Telephone and Radio Co. shown soldering transformer terminals. A precision operation made so simple that even unskilled operators can achieve excellent results on a production basis.



**Electronic Tube Generators—1 KW; 2½KW;  
5 KW; 10 KW; 20 KW; 30 KW; 50 KW; 75 KW; 100 KW.  
Spark Gap Converters 2 KW; 4 KW; 7½ KW; 15 KW; 30 KW.**

WRITE FOR THE NEW LEPEL CATALOG . . . 36 illustrated pages packed with valuable information.



All Lepel equipment is certified to comply with the requirements of the Federal Communications Commission.

**LEPEL HIGH FREQUENCY LABORATORIES, INC.**

55th STREET and 37th AVENUE, WOODSIDE 77, NEW YORK CITY, N. Y.

such specifications for the most popular alloys.

### Quality Control

Control of quality of investment castings is a mutual problem of the producer and consumer and many difficulties have arisen because one has not fully understood the problems of the other. In "Some Requirements for Quality and Process Control of Investment Castings", Charles Yaker, Misco Precision Casting Co., outlined the best procedure to use to obtain the necessary quality of castings at the lowest cost.

The first step is to reach agreement on the material specification, dimensional tolerances on both the sections that will be machined and those that will be used as cast, the surface finish requirements and methods of inspection. There is usually no difficulty with alloy specifications if a conventional casting alloy is used; a problem does arise when the customer wants to change from a wrought form to an investment casting and use the same analysis. Usually the foundry will request a deviation of composition or suggest a substitute material that will have better castability and soundness.

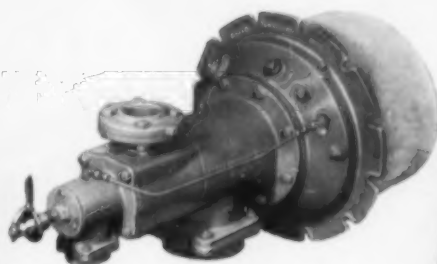
Requirements on dimensions and finish should be indicated on a blueprint submitted with the request for quotation. It may be necessary for the foundry to request some deviations because of their experience with similar parts or because of limitations of process. For example, each casting has to be gated and neither normal dimensional tolerances nor surface finish can be maintained in the area occupied by the gate. When the dimensions are approved, the customer should check at least two sample castings before production begins to give final approval of the master patterns and the dies to be used.

The major hurdle in setting inspection standards is the establishment of kind and number of surface defects to be permitted and their location. In turbine blades, the areas along the leading and trailing edges and the fillet intersection of the airfoil to the buttress platform are sections under high vibrational loads where any imperfections could originate a fatigue failure. Therefore, no imperfections like nicks, pits, cold shuts or grind marks, are

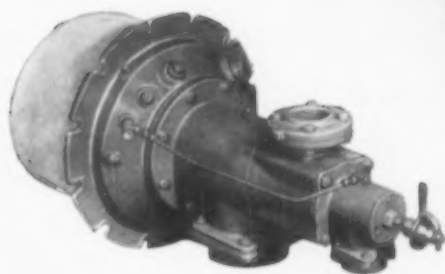
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**That's why it pays you to use this hydraulic-setting refractory for temperatures to 3000F**

Blazecrete® materially reduces labor costs for refractory maintenance. This hydraulic-setting refractory saves time in building and repairing linings for high-temperature equipment.

For troweling, just mix Blazecrete with water as you'd mix ordinary concrete... then slap-trowel it in place. When gunned, it adheres readily with a minimum of rebound loss. Either way, Blazecrete goes on fast, without laborious ramming or tamping. And Blazecrete linings last.

Three types of hydraulic-setting Blazecrete are available. All harden on air curing, do not require preheating. They are furnished as a dry mix—can be stored safely for use as needed.

**3X BLAZECRETE**—For temperatures through 3000F. Unusually effective for heavy patching, especially where brickwork is spalled or deeply eroded. Excellent for forge furnace linings, lime kilns,

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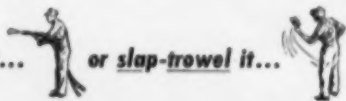
**STANDARD BLAZECRETE**—For temperatures through 2400F. Makes repair work easier and less costly. Can be used by boiler manufacturers to replace fire clay tile in wall construction. Suitable for use in combination with 3X Blazecrete and L. W. Blazecrete.

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Send for Brochure RC-28A on Blazecrete and its companion material, Firecrete®... the hydraulic-setting castable refractory for making special shapes and linings. Write Johns-Manville, Box 60, New York 16, N. Y. In Canada, 199 Bay St., Toronto 1, Ontario.



Whether you gun it... or slap-trowel it...



## Johns-Manville BLAZECRETE

**BUILDS BETTER REFRACTORY LININGS**

## Investment Castings...

permitted. On the sections to be machined, imperfections can be present if they do not extend below the depth of the stock to be removed. Either X-ray or fluorescent penetrant inspection or both are used to control nonvisual imperfections and the standards for acceptance should be set in advance.

Mechanical properties are measured on test bars cast at the same time as the castings. Sometimes every batch of castings must include test bars; for less critical applications, it may only be necessary to test the properties of the master melt for approval of all batches cast from it. The number of such tests should be specified in advance since excessive testing can increase the cost to an extent that the operation becomes uneconomical.

### Inspection

Inspection methods are used to be sure that no casting that will fail prematurely is put in service. Unfortunately disagreements often arise because of different interpretations of test results. This problem was discussed in "Nondestructive Inspection Methods" by B. W. Duncan, Alloy Precision Casting Co.

Radiographic standards are the most costly to maintain and the most frequently misunderstood. In most foundries, X-ray inspection is used to locate defects in initial foundry production in order to determine whatever gating and other revisions may be necessary before full production begins. Subsequent X-ray inspection should be limited to spot checks to be sure that processing variables have been maintained constant. Inspection of each part is expensive and it is not justified for most castings produced by reputable foundries.

Standards are difficult to establish and should be based on the appearance of the radiograph of the worst looking part that will meet service requirements. Both the foundry and customer should have copies of films which show the size and location of acceptable and unacceptable defects and the interpretation of films should be assigned to an experienced radiographer or metallurgist.

Magnaflux and penetrant inspection methods are also most useful

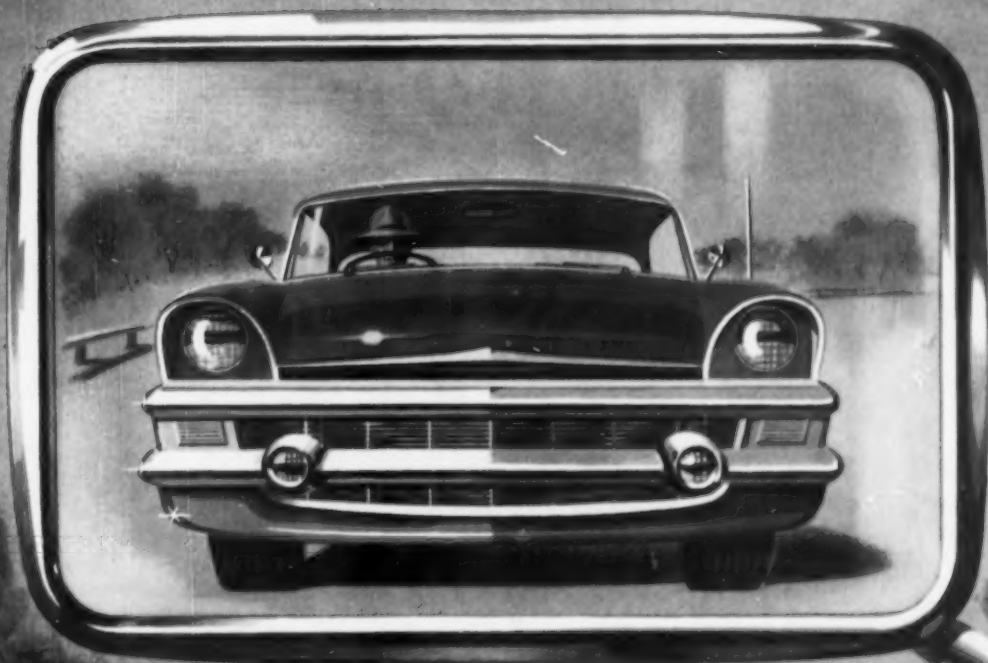
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They have the solution to almost any non-ferrous alloy problem you can name—whether it's tension or temper, fatigue resistance or surface finish.

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## Investment Castings . . .

for establishment of correct foundry practice and as a check on foundry control. They can give false indications of defects and it is advisable to grind the surface lightly at such indications to be sure they are not caused by surface roughness. Unlike X-rays, these inspection tools will only reveal defects that are open to the surface.

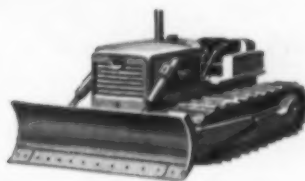
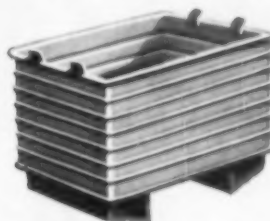
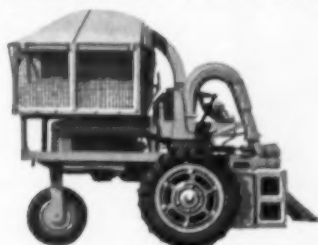
Nondestructive tests cannot by themselves predict the serviceability of an investment casting. They require comparison with known acceptable standards and good judgment by the inspector. Of even greater importance is the free exchange of information between the foundry and the customer concerning the foundry variables which limit the quality obtainable in investment castings and the service conditions which set the lowest limits on the quality acceptable to the purchaser for a specific casting.

## Chromate Coatings for Magnesium Alloys

Digest of "Electrolytic Coatings on Magnesium-Base Alloys From Alkaline Chromate Solutions", by F. Ogburn, H. I. Salmon and M. L. Kronenberg, *Plating*, Vol. 42, March 1955, p. 271-274.

THE LIGHT WEIGHT, low cost and ready availability of magnesium alloys would make them extremely desirable for many structural applications if an inexpensive method of protecting them against corrosion could be devised. Protective finishes now used include two produced by electrolytic or anodizing processes; one uses a proprietary acid chromate solution and the other, called the HAE process, requires a solution of five different chemical compounds. Both of these finishing methods require a relatively high-voltage power supply.

Another electrolytic process covered by a patent issued in 1943 was recently re-evaluated at the National Bureau of Standards and was found to have several important advantages providing that operating variables were properly controlled. Good protective coatings could be produced



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- It is 50% stronger than mild steel.
- It is considerably more resistant to corrosion.
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- It is readily and easily welded by any process.
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And, with all these physical advantages over mild carbon steel, it can be cold formed as readily into the most difficult shaped stamping.

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**TWO ...**



**THREE ...**

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This program is cutting costs for manufacturers because . . . it means they can dis-assemble their conveyors for use in other plant locations . . . it means conveyors can be modified in almost any way at minimum cost.

Pre-fabricated sections are available rapidly and inexpensively. Straight sections . . . concave or convex sections . . . take-up charge and discharge-end sections can be furnished to meet specific requirements of belt width as well as load bearing and volume capacities.

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for complete  
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## Chromate Coatings . . .

from an aqueous solution containing only sodium or potassium hydroxide and the corresponding chromate. The voltage required is only 10 to 12 v. a-c. in comparison to about 100 v. used in the other two anodizing treatments.

Since alternating current is used, the coating is formed on both electrodes. With a current density of 80 to 140 amp. per sq.ft. and solution temperature of 150 to 170° F., a coating 0.001 to 0.002 in. thick is formed in 20 to 40 min. on each electrode. The coating is smooth and hard but not as uniform as either the acid chromate or HAE finish. In salt spray exposure tests the alkaline chromate treatment was about as protective as HAE coating and considerably superior to the acid chromate treatment. In a 12-day exposure test, the average number of corrosion spots was 6, 9 and 49 for the alkaline chromate, HAE and acid chromate coatings, respectively. For longer periods of exposure, differences between the protective value of the alkaline chromate and HAE finishes were less distinct.

For good protection against salt spray corrosion, both current density and temperature must be controlled carefully. Variations in current density between 80 and 140 amp. per sq.ft. have little effect but lower densities produce coatings with inferior protective value. Increasing the temperature of the bath above that required for complete coverage also reduces the corrosion resistance of the coating. As the time of electrolysis is increased up to about 30 min., at which time the coating is about 0.0016 in., corrosion resistance improves. Longer times have only a minor effect on corrosion protection and after periods longer than about 60 min., the coating flakes off in the bath.

As part of the investigation, several organic coatings were tested for adhesion to the chromate coating. The adhesion was satisfactory if the specimens were not subjected to bending or flexing. When the panels were bent, loss of adhesion occurred on coatings 0.0005 in. or more in thickness because of the failure of the electrodeposited coating. However, the adhesion is satisfactory on thinner coatings.



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TENSILMARK for rapid and accurate scribing of gauge marks on specimens.

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- STANDARD BRINELL TESTS
- STANDARD VICKERS TESTS

## WITHOUT

Microscopic Measurement  
of the Indentations



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REFLEX Machines with  
Carl Zeiss automatic  
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Also investigate Morehouse Ring  
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## HOW OFTEN SHOULD TESTING EQUIPMENT BE CALIBRATED?

... frequently, to maintain true dependability. To achieve the ultimate in reliability, many manufacturers insist on periodic checking with Morehouse Proving Rings.

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for rapid, accurate  
non-destructive  
**THICKNESS MEASUREMENTS**  
from one side  
and accelerated  
**METAL CLEANING**

## VIDIGAGE®

### AUTOMATIC THICKNESS GAGE

21" Cathode-Ray Tube;  
Direct-Reading Scales;  
Any Range between 0.005" and 2.5";  
Accuracies from 0.1% to 1.0%;  
Cables up to 1000 feet for remote testing.

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### PORTABLE THICKNESS GAGES

Battery-Operated; wide thickness range;  
Model 5, 0.040" to 12"; Model 5a, 0.040" to 12";

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### ULTRASONIC-POWER GENERATORS

for fast, thorough metal washing and de-greasing;  
Outputs from 100 Watts to 25 KW.

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on Request

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## Inspection Demagnetizing or Sorting PROBLEMS?

**SOLVED with**

### MAGNETIC ANALYSIS MULTI-METHOD EQUIPMENT

Electronic Equipment for non-destructive production inspection of steel bars, wire rod, and tubing for mechanical faults, variations in composition and physical properties. Average inspection speed 120 ft. per minute.

Over 50 steel mills and fabricators are now using this equipment.

### MAGNETIC ANALYSIS SPECIAL EQUIPMENT

Electronic Equipment for non-destructive production inspection of non-magnetic stainless steel bars, and both seamless and welded tubing for mechanical faults, and for variations in composition and physical properties. Average inspection speed 200 ft. per minute.

### MAGNETIC ANALYSIS DEMAGNETIZERS

Electrical Equipment for rapid and efficient demagnetizing of steel bars and tubing. When used with Magnetic Analysis Multi-Method Equipment, inspection and demagnetizing can be done in a single operation.

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Electronic Instruments for production sorting both ferrous and non-ferrous materials and parts for variation in composition, structure and thickness of sheet and plating.

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Inexpensive pocket meters for indicating residual magnetism in ferrous materials and parts.

TRADE MARK



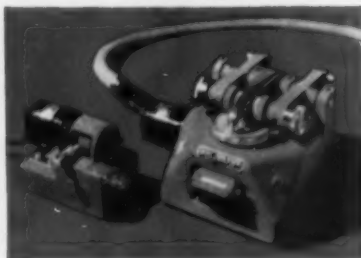
For Details Write:

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"THE TEST TELLS"

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## Your LABORATORY CAN MAKE *Accurate* ABRASION RESISTANCE TESTS



### with the TABER ABRASER

Simulates ACTUAL abrasion and wear conditions during test and gives ACCURATE numerical index for your report. Recognized the world over as the STANDARD for testing metals and metal finishes. The Abraser is now available in the NEW portable type Model 140-PT, illustrated above.

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Determines both stiffness and resilience of sheet and wire specimens and gives report from DIRECT READING. No calculations!

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### HARDNESS TESTING SHORE SCLEROSCOPE



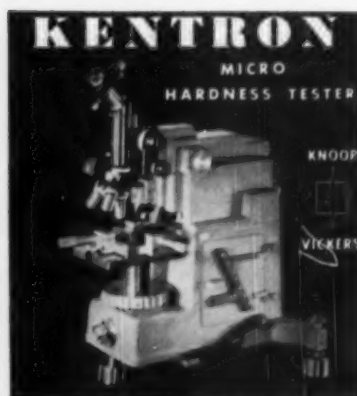
**Pioneer American  
Standard Since  
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Available in Model C-2 (illustrated), or Model D dial indicating with equivalent Brinell & Rockwell C Hardness Numbers. May be used freehand or mounted on bench clamp.

**OVER 40,000  
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Star Stainless screws have  
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CORROSION  
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Non-flammable  
Non-toxic  
Aqueous Oily Film  
Protects Ferrous Parts  
for Long Periods  
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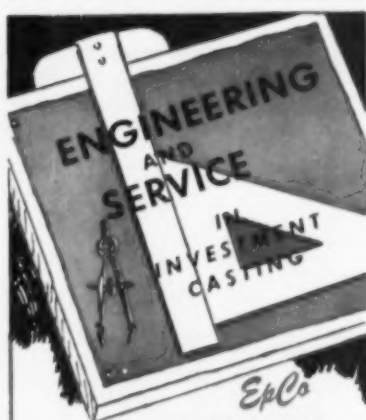
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Complete Arc Welding Accessories

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STAINLESS STEEL PART for milk  
bottling unit formerly machined  
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Only finish operations  
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Special Feature  
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- All Analyses
- Coated, Straightened
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BRIGHT GOLD  
PLATING**  
*without scratch  
brushing or  
buffing!*

**GOLD  
SILVER  
RHODIUM**

*Write for complete details*



## BRIGHT GOLD PROCESS

**FOR INDUSTRIAL and  
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1. Exceptionally hard deposits — twice the hardness of conventional gold plating.
2. Operates at room temperature — requires absolute minimum control.
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**Grade "B"**

**FERROUS  
METAL PROCESSING**

Eliminates . . .

**Rust  
Fire Hazards  
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Dermatitis  
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Finishing Wheels — Diamond Wheels**

Custom-made for your specific  
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**Foundry Snagging—Billet  
Surfacing—Centerless Grinding**

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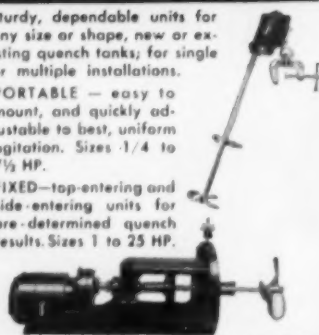
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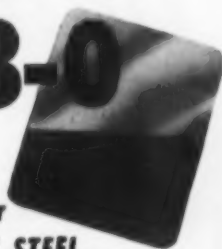
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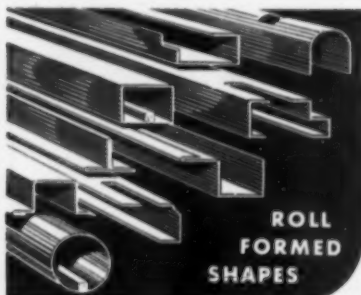
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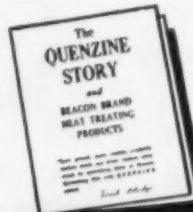
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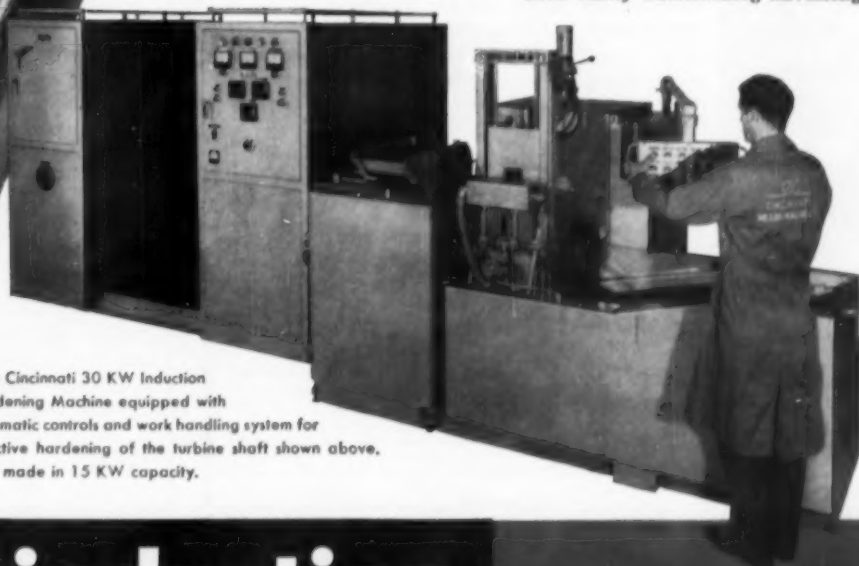
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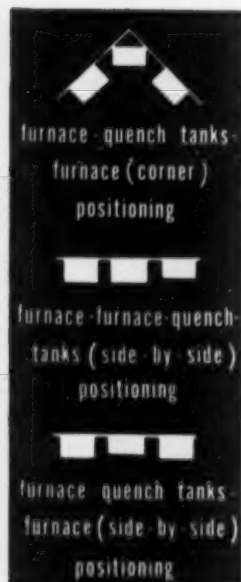
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## Cathodic Protection

Digest of "Economic Cathodic Protection", by Benson G. Brand, *Corrosion Technology*, Vol. 3, January 1956, p. 12-14.

**C**ORROSION costs our country billions of dollars annually. Scientists are constantly attempting to control this loss by developing new methods to reduce the waste, largely on iron.

Three of the methods used to limit the rate of corrosion are: (a) Substitute a corrosion resistant material when possible, (b) cover the material with an organic coating, and (c) use cathodic protection. A fourth method that employs the latter two items is considered in this paper.

Basically, metallic corrosion is an electrical process. Protection against corrosion may be obtained by sealing the metal surface to prevent an electrolyte from penetrating to the metal. Cathodic protection is accomplished either by placing a sacrificial anode near the metal to be protected or by creating a current from an external source. An adequate current density for protecting a steel surface is 2 to 4 milli-amp. per sq. ft. Soft water protects metals. It has no current density because of the absence of dissolved salts. Meanwhile, hard water, like sea water, carries current greatly in excess of that needed for protection. The required current can be greatly reduced by coating the surface to be protected. Then only the small areas, as faults and pinholes, will demand small currents. Here savings can be made by reducing the consumption of sacrificial anodes.

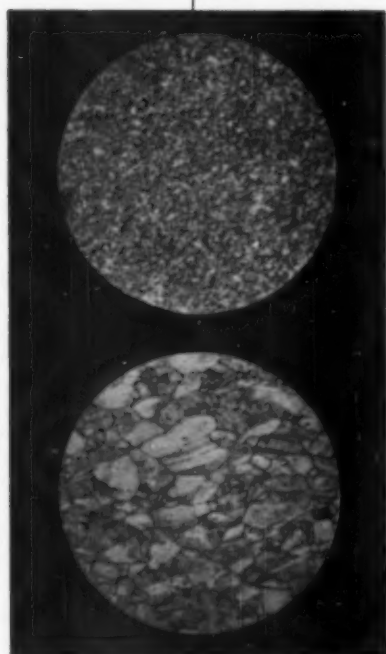
The primary purpose of the coating is to decrease the amount of protective current required. Exceptional instances may require a coating to be decorative or antifouling. In conjunction with cathodic protection no one coating is universally used for any specific application.

Steel in contact with sea water is easily corroded. In offshore drilling equipment the types of exposure present are: atmospheric, with salt spray and petroleum products; tidal, having periodic exposure to atmosphere and water; and marine, with a continual exposure to water. Such equipment requires a vinyl coating for cathodic protection by

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5576

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## Cathodic Protection . . .

minimizing the exposed surface. The coating is generally composed of a thin layer of polyvinyl butyral-zinc chromate-phosphoric acid type of wash primer applied on a cleaned steel surface and followed by a coating 6 mils or more thick of an air-dried vinyl chloride-vinyl acetate copolymer-type coating. On ship bottoms the type of exposure varies according to where the ships are being operated, as in fresh, contaminated and sea waters. Such hulls require an antifouling organic coating which is toxic to marine organisms. The binder used to contain the toxic material slowly leaches away and leaves a constantly renewed supply of toxic material on the surface of the hull. Sacrificial magnesium anodes are always carefully placed on the hull so cathodic protection of the steel does not upset the mechanics of the coating. Magnesium anodes have performed satisfactorily on the hulls of ships for several years.

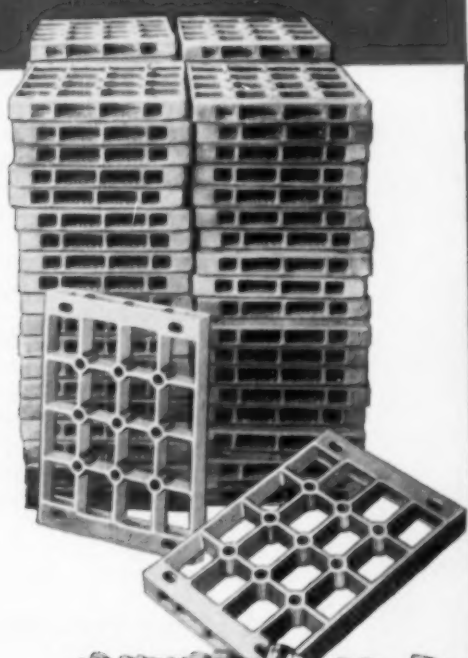
Extensive cooperative tests by the U.S. Bureau of Ships and the Maritime Commission have been under way on an impressed voltage from a series of rectifiers to the mothball fleet of the U.S. Navy. The best protection found is an insulating coat to decrease the area of the ship's hull exposed to the electrolyte, in conjunction with a high current density for protection in voids and damaged areas.

Buried pipelines carrying gas and petroleum products are vulnerable to the corrosive attack of soils ranging from highly alkaline to very acidic conditions. The cathodic protection of pipelines by means of an applied potential is one of the major accomplishments of this method. Present protection on pipe is to apply a coat of asphaltic or coal tar pitch 1/16 to 1/8 in. thick, followed by a spiral wrapping of paper and a second application of thermoplastic coating over the paper. With the protective current required greatly reduced, an adequate current density is still maintained to protect the pipes at breaks or flaws in the coating. A serious limitation to using this method is that flaws can occur on coatings (which have fairly low softening points) of the pipe at the discharge end of compressor sta-

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HEAT AND CORROSION *Alloys*

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Plants at Springfield and Lima, Ohio

OFF

## Cathodic Protection . . .

tions where the gas temperatures often reach 300° F. A good practice is to carefully fill the trench around the pipe, to insure that no abrasive material, such as rocks, will rupture the coating when the pipe expands or contracts with temperature changes. Vinyl tape coated with a pressure-sensitive adhesive has been wrapped successfully over pipelines. Such tape is about 10 to 20

mils thick, and is supplied in widths up to 24 in.

Other installations where corrosion is the major problem are water boxes of large boiler condensers, containers for heavy-duty transformers, and domestic hot water tanks. In the corrosion of cast iron water boxes, galvanic effects are set up where the cast iron serves as the anode to protect the tubes made of a corrosion resistant alloy. Cylindrical magnesium anodes in the coated water box have been successfully

used to stop corrosion of both tubes and water box. Tests under way for five years showed no visible signs of corrosion on an installation having a carbon steel water box, Monel tube sheets and cupronickel tubes.

As for coatings on containers housing the heavy-duty transformers, cathodic protection is still being investigated, since no protective coating has been found to last for anywhere near the lifetime of the transformer. Protection on these is complicated since they are subject to complete or partial immersion in sea water at temperatures as high as 140° F. Cathodic protection of domestic hot water tanks has been achieved by suspending a magnesium rod in the center of the tank as a sacrificial anode. Here, the magnesium dissolves in the water as a harmless salt. An insulating coating on the interior of a hot water tank can be helpful but only in conjunction with cathodic protection since a continuous coating is difficult to make around the fittings and weld zone areas.

In many instances protection cannot be obtained by any single method, encouraging the use of two or more methods in conjunction. When a coating can meet all the fundamental requirements such as resistance to cathodically produced products, a high electrical resistance, a high resistance to water-borne chemicals, and to special conditions, large savings can be realized.

J. M. H.

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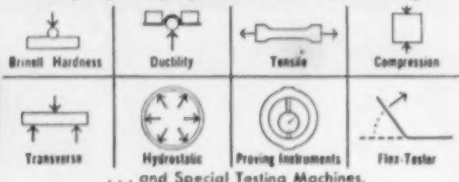


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## A Strong Weldable Steel

Digest of "The Performance of High-Strength Pressure Vessel Steels", by J. H. Gross and R. D. Stout, *Welding Journal*, March 1956, *Welding Research Supplement*, p. 115-8.

**P**RESSURE vessels used in America are limited by code to the use of plain carbon steels. However, pressures are continually increasing, and wall thicknesses up to 12 in. are in prospect unless stronger steels are permitted. In an attempt to meet this situation the Pressure Vessel Research Committee has sponsored studies into improved design methods, welding procedures, fatigue resistance of the metal and its mechanical properties. The article by Messrs. Gross and Stout examines

the latter for seven steels received as 1-in. plate, including a hot rolled plate of the standard mild carbon steel corresponding to A.S.T.M. specification A 201. This digest will be limited to a review of the properties of what is apparently the best of the new steels, called 90 B, received in the quenched and tempered condition. Its analysis was 0.15% C, 0.93% Mn, 0.27% Si, 0.89% Ni, 0.48% Cr, 0.44% Mo, 0.06% V, and 0.003% B. Comparative tensile properties at room temperature are shown alongside.

In general the yield of the high-strength steels is much closer to the ultimate than the low-carbon steels, and elongation is progressively lower; reduction of area does not vary significantly.

When the tension tests are made at elevated temperatures the tensile strength is not affected much until 600° F. is passed (except for A 201 which has a peak at 550). Yield strengths decrease gradually, being about 100,000 psi. for 90 B and 22,000 for A 201 at 650° F. All the steels have reduced ductility in the blue brittle range, 450 to 550° F.; both 90 B and A 201 have recovered most of it at 650° F. (Most codes permit service operation to 650° F. without reduction of design values based on room-temperature tests, despite this very considerable embrittlement that takes place at about 450° F.)

Toughness of the plate was appraised by making Charpy impact tests at various temperatures and noting the transition from fine to coarse fracture. The greatest drop in transition temperature in all the steels was caused by "strain aging" — stretching 5% and then reheating to 550° F. for 1 hr., a routine which simulates the forming and stress-relieving operations during fabrication. Transition temperatures are tabulated at the top of the page.

These and other data in the article show that the quenched and tempered alloy steels tested resist the effects of strain aging fairly well, and inferentially are insensible to normal fabrication processes other than welding.

To check on the latter, welded joints were made with electrodes and techniques recommended by other researchers. Restraint tests indicated the maximum width of specimen at which weld metal cracking would begin. Neither A 201 nor 90 B showed cracking at the maximum width of 8 in. Five specimens of each steel were studied in a test to indicate underhead cracking (usually ascribed to hardenable microconstituents in the weld metal). As expected, welds in A 201 contained no such cracks; welds in 90 B aver-

Tensile Properties		A 201	90 B
Tensile strength		54,800 psi.	123,600 psi.
Yield (0.2% offset)		29,700	114,000
Elongation in 8 in.		33.8%	13.9%
Reduction of area		65.8%	57.5%
Transition Temperature		A 201	90 B
As received		+ 30° F. (a)	-195° F. (b)
Strain aged		+130	-160
Single stress relief		+ 40 (c)	-190 (d)
Quadruple stress relief		+ 35	-195
24-hr. stress relief		+ 50	-180
(a) As rolled. (b) Quenched and tempered.			
(c) 1 hr. at 1150° F. (d) 10 hr. 900° F.			

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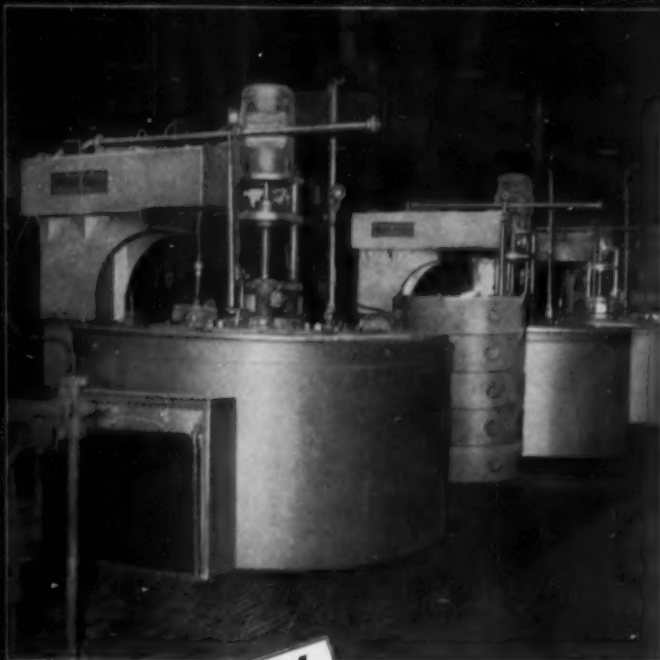
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## Weldable Steel . . .

aged 39% cracks, largely due (in the authors' opinion) to dilution of the metal deposited by the qualified electrode by alloy from the steel alongside the joint.

To insure toughness of the welded joints the plates are commonly preheated, or the joints postheated. Measurements of these effects were made with the Kinzel test (transition temperature at 1% lateral contraction). Results for the two steels were as follows:

	A 201	90 B
As received	-120° F.	-225°
As welded	- 30	- 80
Welded at 300°	- 30	-105
Postheated once	- 30	- 90
Four times	- 20	-120

The authors conclude that quenched and tempered alloy steel 90 B (when compared with the standard low-carbon steel (A 201) has twice the tensile strength, three times the yield and half the elongation when tested at 70° F. and equally satisfactory properties at elevated temperature; it has only slightly greater tendency to weld cracking, substantially superior notch toughness in all conditions, and minimum susceptibility to base-metal embrittlement.

## Size Effects in Fatigue Testing

Digest of "Investigation of Notch Size Effects on Rotating Beam Behavior of 75 S-T 6 Aluminum Alloy", by W. S. Hyler, R. A. Lewis and H. J. Grover, Technical Note 3291, National Advisory Committee for Aeronautics, November 1954.

THE AMOUNT of useful design information that laboratory fatigue tests on small specimens may provide for large structures or components is not known. Evidence exists that large specimens may have significantly lower fatigue strengths than small test specimens of the same material. It also appears that notches in large specimens may have more detrimental effects than geometrically similar notches in small specimens. Unfortunately reliable design rules on such size effects have been lacking because published informa-

tion on notch effects in fatigue behavior is not in complete agreement.

The present investigation was planned to study general size effects upon the fatigue behavior of a specific aluminum alloy of major interest in aircraft design, 7075 (75 S).

Unnotched and notched specimens with minimum section diameters of  $\frac{1}{8}$ ,  $\frac{1}{4}$ ,  $\frac{1}{2}$ , 1 and 1½ in. were tested. For each size a semicircular notch having a theoretical stress concentration factor of 2.0 was used. In the 1½-in. diameter specimens, a 60° V-notch having a stress concentration factor of about 19 was also tested.

The average mechanical properties obtained on specimens from 3-in. diameter bars of the material were: tensile strength 87,000 psi.; yield strength 79,200 psi.; 12.2% elongation; 16.6% reduction in area and an elastic modulus of  $10.5 \times 10^6$  psi.

The surfaces of all specimens were prepared by (a) lathe turning and then mechanically polishing with 600-grit emery dust in cutting oil to remove 0.0015 to 0.0025 in., (b) a second mechanical polish with chromium oxide rouge suspended in kerosene to remove 0.0005 to 0.0010 in., and (c) a final electrolytic polish to remove an additional 0.0003 to 0.0005 in.

Electropolishing was used because preliminary results indicated the existence of an appreciable layer of disturbed metal after mechanical buffing. Although electropolishing removed some disturbed surface material, the resulting surface was not entirely free of small pits. The size of these pits was not given.

A comprehensive tabulation of experimental data for each group of specimens is appended to the report together with photographs of equipment and specimens. Complete sets of S-N curves and size effect plots are also included.

The following specific conclusions are reported:

1. Tests on unnotched and notched specimens from  $\frac{1}{8}$  to 1½ in. do not show systematic evidence of over-all size effect or of notch size effect. The significance is limited by the scatter of test results, particularly for unnotched specimens.

2. A small radius notch in the large (1½-in.) diameter specimen produces a relatively small fatigue-strength reduction ( $K_f$  about 1.8) in spite of its large theoretical stress

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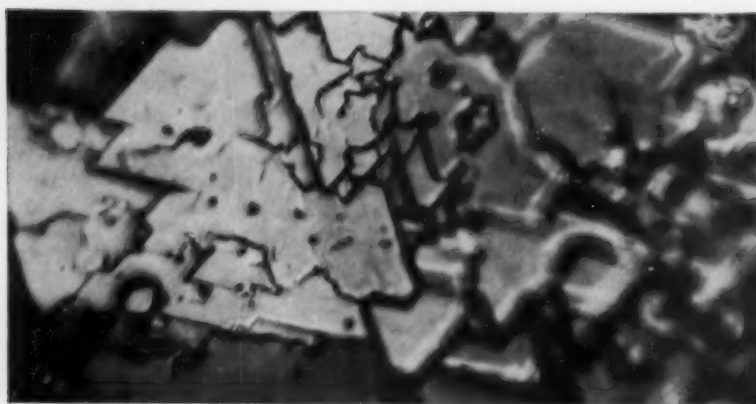
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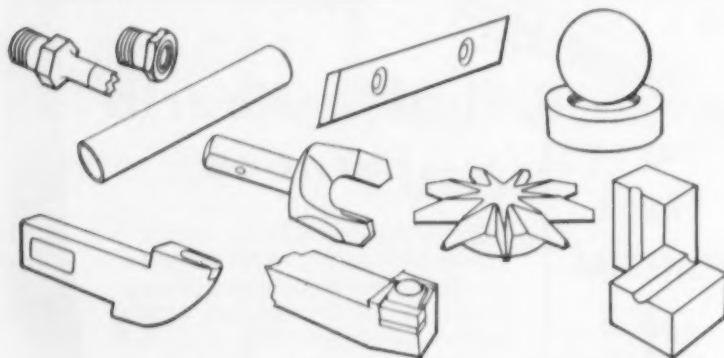


**WTiC<sub>2</sub> Crystal (4000X).** Photomicrograph of Kennametal tungsten-titanium crystal (4000X). This unique material is an important ingredient of Kennametal, and provides a combination of desirable characteristics in the steel-cutting and gall-resistant grades of Kennametal.

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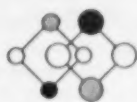
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concentration factor ( $K_t$  about 19).

3. The effects of specimen size and notch size upon fatigue behavior of aluminum alloys is still not fully understood. It appears that scatter in the observed fatigue strengths presents the chief difficulty. More attention should be devoted to the study of surface finish and statistical evaluation of results in future work.

W. W. AUSTIN

## Oxygen Steelmaking

Digest of "The Oxygen Steel-making Process", by D. O. Davis, presented at the Birmingham Regional Technical Meeting of the American Iron and Steel Institute, Oct. 5, 1955, 16 pages.

PRODUCTION OF "oxygen jet steel" in two 40-ton vessels working on 45-min. heat times can match the output of four 250-ton openhearth, roughly 100 tons per hr. Furthermore the oxygen steel plant, complete with gas generation facilities, can be built for half the cost of the openhearth shop. The oxygen steel ingots have been described as superior in some tests to the best openhearth steel.

The so-called oxygen process of steelmaking takes place in a one-piece, open-top vessel, free to rotate on trunnions. High-purity oxygen, at a pressure of 5 to 10 atmospheres, is blown downward to the surface of the molten iron bath. The reaction between the oxygen and the surface of the bath is almost explosive and results in very high temperatures and gas velocities. Oxygen is introduced through a water cooled jet or lance whose dimensions are a function of vessel size and desired heat time. Charges for the oxygen vessel include both scrap and hot metal.

The vessels are of one-piece design, built of 2-in. plate, 14 ft. in diameter and 25 ft. in height. Magnesite brick is used for the permanent lining and is backed up by fire-clay. The working lining is made of 100 tons of tar dolomite brick with a backing of rammed tar dolomite. Working volume of the vessel with a new lining is 1150 cu. ft. This increases to 1650 cu. ft. as the lining wears. For a 45-ton charge, the depth of the bath varies from 32 to 30 in. as the lining thickness changes.

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## Steelmaking . . .

Average lining life is 180 heats, but 250 heats may be obtained with improved practice.

After the vessel is charged and turned upright beneath the dust collector hood, the oxygen lance is lowered and the blast is admitted. The oxygen on-time is 22 min. per heat, with a total tap-to-tap time of 45 to 50 min. Oxygen consumption is

about 1850 cu. ft. per ton of steel produced.

The dust collection system comprises brick-lined vessel stacks 124 ft. high, from which ducts feed waste gases to cooling boxes, collector mains and cyclonic separators. High and low-pressure water sprays are strategically placed to clean the gases which range in volume from a minimum of 110,000 cu. ft. per min. at 65° F. to 120,000 cu. ft. per min. at 115° F. Average temperature in

the main stack over the vessel is 1600° F.

Success or failure of the oxygen jet process depends on the oxygen supply facilities. The unit at Dominion Foundries & Steel, Ltd. produces 100 tons of high-purity (99.5%) oxygen per day with a power consumption of less than 400-kw-hr. per ton of oxygen.

Nitrogen content of the finished steel is a function of oxygen purity. With oxygen 99.5% pure, nitrogen in the steel has been 0.0025% or less. Further, the oxygen content of the steel is definitely less than in open-hearth practice.

To date, all the low-carbon rimmed and mechanically capped grades of steel for hot and cold strip mills have been made by the oxygen jet process, as well as skelp and other rimmed and killed grades for hot rolled plate and strip products up to 0.20% carbon. Strip analyses average 0.06 to 0.10% carbon, 0.30 to 0.40% manganese, 0.025% sulphur and 0.015% phosphorus.

ARTHUR H. ALLEN

## Scientists . . .

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A word from  
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## Barrel Finishing for Burr Removal

Digest of "Investigation of Barrel Finishing as a Means of Efficient Burr Removal", by Charles E. Kincaid, *General Motors Engineering Journal*, Vol. 3, No. 1, January-February 1956, p. 34-39.

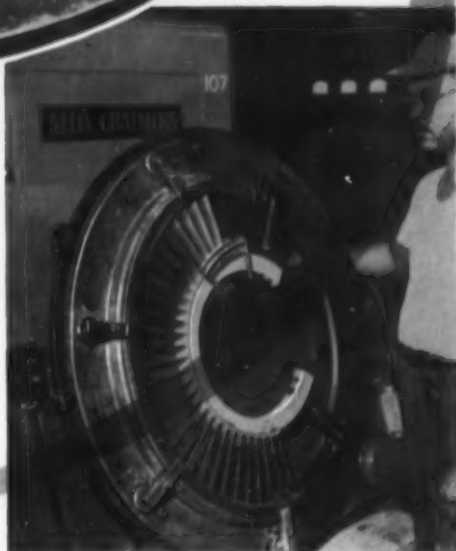
**B**URRS can be removed from precision metal parts before plating or assembly at a high production rate by barrel finishing, a process which became popular during World War II for finishing of aircraft engine components.

In barrel finishing, the parts are placed in an octagonally shaped barrel with water, a cleaning compound and a medium. The latter is the abrasive material which does the finishing. The barrel is rotated at a predetermined speed, possibly in the range of 10 to 30 rpm., for a fixed time. As the barrel rotates, the flat sides lift the enclosed mass to a height from which it slides to the opposite side of the barrel. During this slide, the parts are subjected to a grinding or polishing action by the sliding medium.

Some type of cleaning compound is essential in wet barrel finishing.



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or 28 joints, is 10 minutes. Blades are *nickel steel* and shroud ring is *brass*. EASY-FLO is particularly effective in joining dissimilar metals. Average strength of joints is *double* the specified minimum pull of 2800 lbs.

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## Barrel Finishing . . .

Such compounds remove oils and greases left on parts from machining operations and they keep the abrasive medium clean and free from metal build-up.

Three basic types of mediums are in common use — natural, (for example, limestone and granite); manufactured aluminum oxide; and various steel shapes. The natural stone

can be used economically for burr removal provided some type of abrasive compound is added. Principal disadvantage is the slow rate of burr removal.

If speed is desired, aluminum oxide or some form of steel shape is advisable as a medium because each breaks down faster than natural materials and exposes more sharp cutting edges. Steel shapes should be used with an abrasive compound. They may be soft or heat treated

for greater hardness. Because they are heavier than other mediums, steel shapes tend to increase the speed of the operation. In the selection of any type of medium, size should be large enough to prevent it from lodging in the part, yet small enough to pass through any hole in the part.

Four different methods of barrel finishing are (a) processing of parts in the loose state (b) use of multiple-compartment barrels (c) use of arbors or fixtures and (d) self-processing of parts. The first is most widely used. Best results are obtained when the barrel is loaded 50 to 60% full of medium and 15 to 20% full of parts. Total mass should not exceed 75% of the barrel capacity.

Care must be exercised on loading and unloading to avoid nicking the work; one technique used is to load only a portion of the parts and then to jog them back and forth several times so they become buried in the medium. A wire basket serves as a good way of unloading, if the mesh is of a size that the medium slides through and the work remains.

The multiple-compartment method is used on parts having a regular or smooth peripheral surface and too large to go through the door opening of machines for loose processing. One disadvantage is the faster breakdown of the medium since the movement of parts in the separate compartments is restricted in that they must remain in one plane.

Arbors and fixtures have been adapted to parts with irregular peripheral surface since the projections might damage both the parts and the barrel lining of multiple-compartment equipment. An example of this application is transmission end plates which were processed 14 per load in a 48-in. barrel for 30 min. at 20 rpm. A keyed hub was placed in the center of each plate and fastened in place by three bolts. This assembly was placed on an arbor and locked in the barrel by a hinged collar attached to the end plates of the barrel. The time required to deburr these parts completely by hand was reduced about 65% with barrel finishing.

Self-processing has been used on small punch press parts where finish was of no importance. The method eliminates the need for separating the parts from the medium at the

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**Inconel\* keeps retorts gas-tight**

According to the builders, proper operation of these high vacuum furnaces calls for gas-tight retorts. They must be so non-porous that it would take 120 years for a thimbleful of air at atmospheric pressure to leak in.

They must *stay* gas-tight, too . . . and keep shape despite pressure . . . despite temperatures to 2000°F . . . despite the tremendous thermal shocks of water-spray cooling . . . despite oxidation, carburization and other forms of attack.

Inconel nickel-chromium alloy is able to handle such an assignment. It has given as much as 5000 hours in these high vacuum retorts without sign of failure.

You may be looking for an alloy like this . . . with high and lasting hot strength plus corrosion resistance. If so, look into Inconel. A new Inco booklet, "Keep Operating Costs Down When Temperatures Go Up", pictures many ways to use Inconel effectively. Write for a copy.

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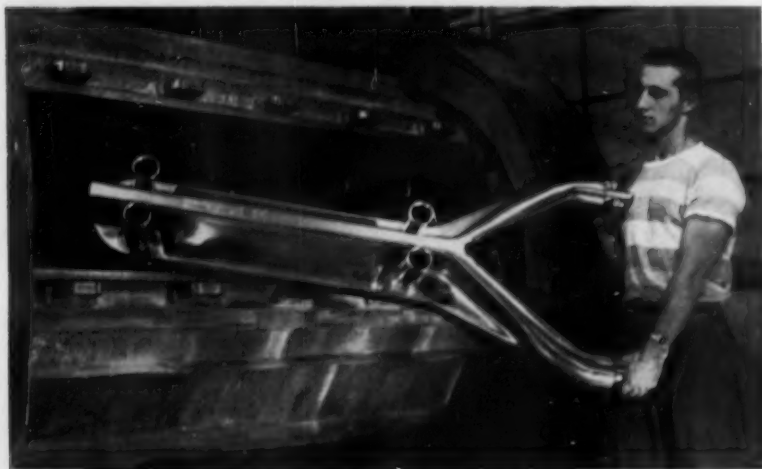
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**...for long life at high temperatures**



Loaded Inconel Retort and part of vacuum producing equipment are lowered into combustion chamber of new vacuum furnaces for heating. After heat treatment, retort is spray cooled in tank in foreground. Despite thermal shock Inconel retort stays gas-tight.

## "40% INCREASE IN LUSTER AFTER USING LORCO COMPOUNDS"



Removing parts from the barrel, after tumbling with Lorco Chips and Compounds.

### How an important Pennsylvania manufacturer saved money and solved an unusual barrel-finishing problem.

A large eastern corporation was exploring the possibilities of barrel-finishing stainless steel frames and heat exchanger units.

These frames, measuring 56" x 25", required specially designed fixtures to hold them in the barrel. The first try, according to the manufacturer, was a dismal failure. Numerous types of compounds and chips in varying combinations were experimented with, but none proved satisfactory and costs seemed prohibitive.

Finally, the only way they could do an acceptable job was to scrub the parts by hand with a brush and a soap detergent after tumbling. *And then they learned about LORCO COMPOUNDS!*

Using fused aluminum oxide chips and Lorco Compounds for 20 minutes, a load was washed down and the parts removed. Immediately it was apparent that the luster was greatly improved. Subsequent examination with a Gardner Glossmeter showed an increase in luster of 40% over anything which had been previously tumbled. In low costs, Lorco compounds were also winners . . . 39% under the costs of other compounds.



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TUMBLING BARRELS — MEDIA AND AUXILIARY EQUIPMENT

## Barrel Finishing . . .

end of the barrel finishing cycle. Abrasive powder was added to the barrel to break the surface tension which might have caused the parts to stick to the sides of the barrel and to each other.

Recommendations for successful barrel finishing include these: (a) Keep the barrel at least half full of medium at all times during the cycle to prevent damage to parts or to lining; (b) for fast cutting of burrs, keep water level low; (c) use only enough cleaning compound to keep parts and medium clean; (d) on ferrous parts a 3 to 1 ratio of medium to parts is a good general rule, although finish requirements may indicate a ratio as high as 6 to 1; and (e) on aluminum parts the ratio of parts to medium should be determined by the size of the individual parts rather than by weight. Maximum utilization of the process can be realized only on volume production when the medium is not changed between runs.

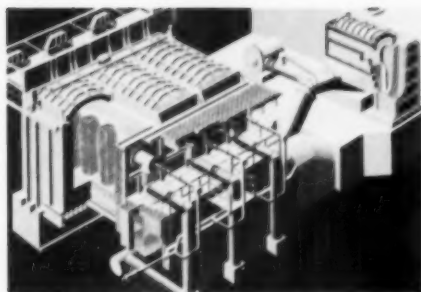
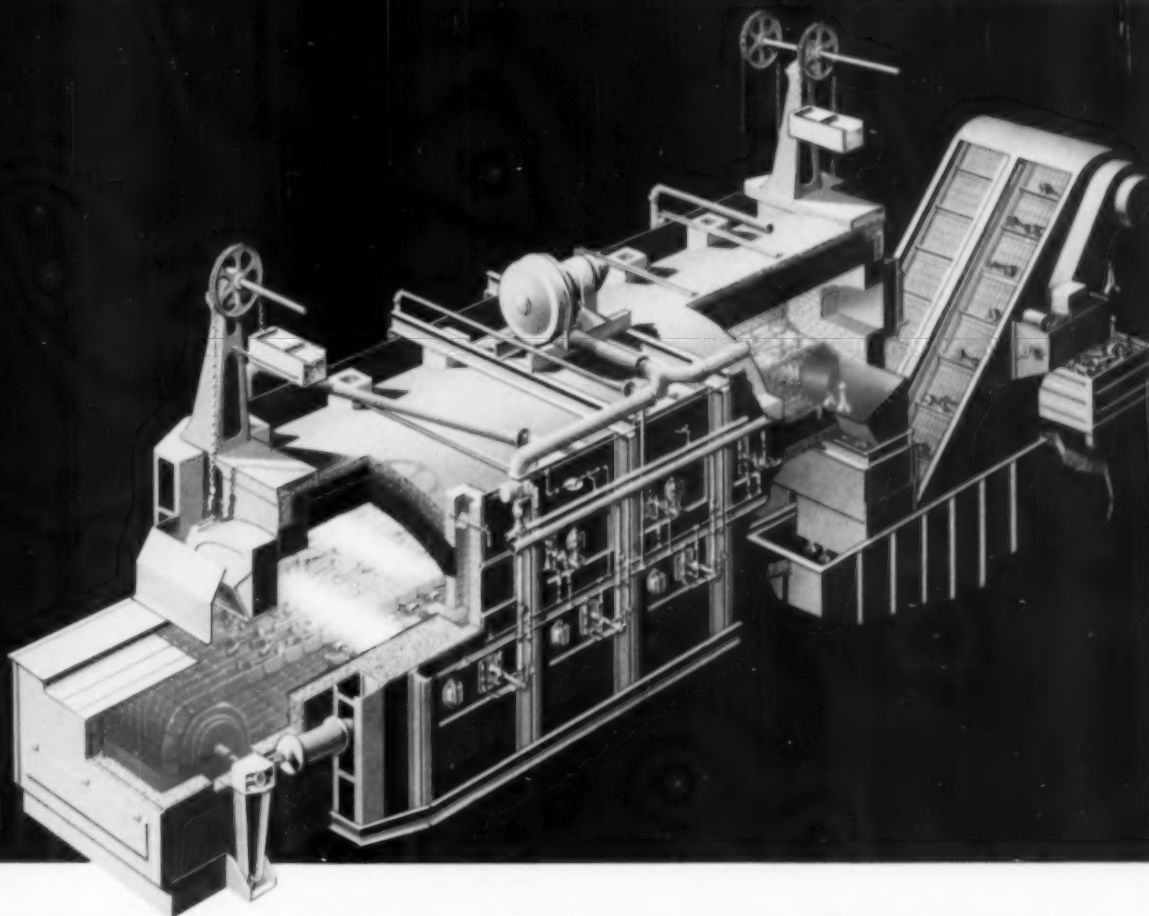
In conclusion, barrel finishing has proved less expensive than hand deburring; it is much faster, it will produce a more uniform over-all finish and will duplicate results from one cycle to the next.

ARTHUR H. ALLEN

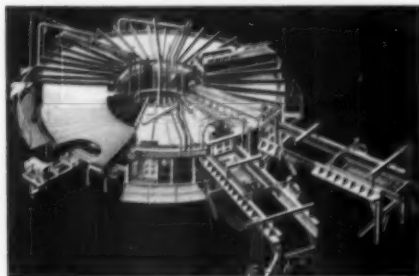
## Stress-Relief of Welded Vessels

Digest of "Controlled Low-Temperature Stress Relieving of Pressure Vessels", by T. W. Greene and C. R. McKinsey, *Welding Journal*, March 1956, *Welding Research Supplement*, p. 145-S.

It has long been known that tensile stresses near the center of a welded butt joint in sizable pieces of steel plate equal or approach closely the yield point, but that these stresses drop sharply within a distance of 2 in. on either side of the weld and are balanced by mild compressive stresses in the body of the plates. If, therefore, a piece, say, 30 in. long and 16 in. wide is cut from such a joint, as shown in Fig. 1, a narrow central strip perhaps 2 in. wide may be regarded as being in heavy tension, but the remainder is, on the average, in mild compression. The



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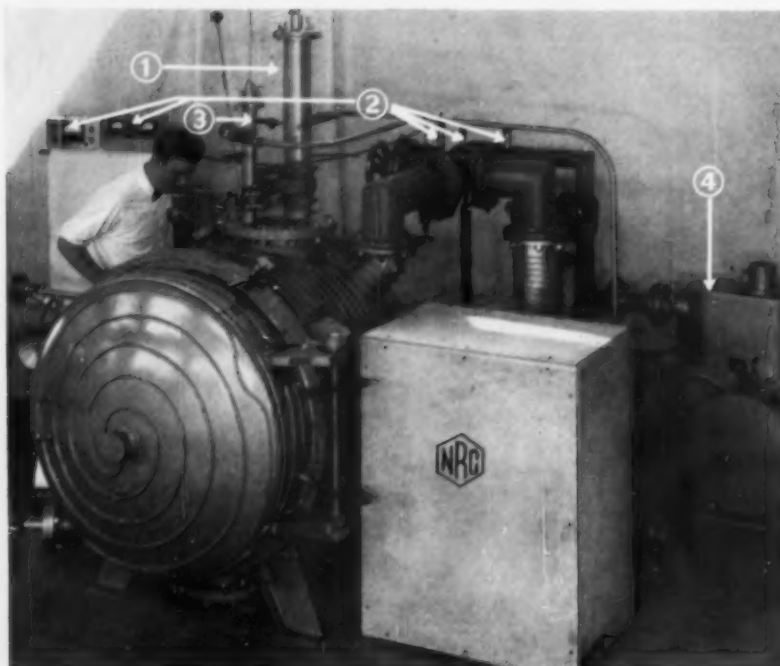
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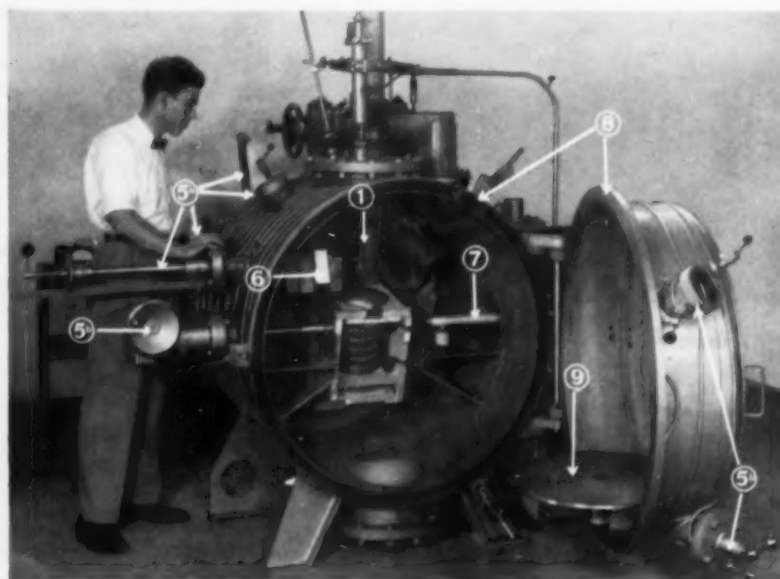
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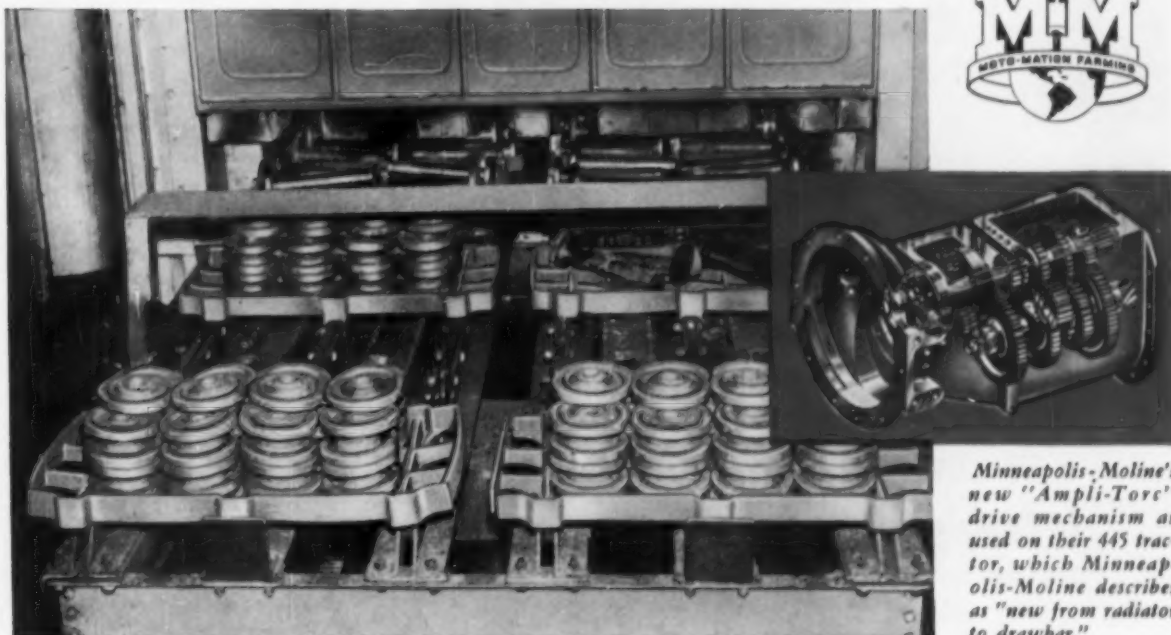
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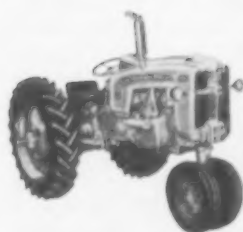
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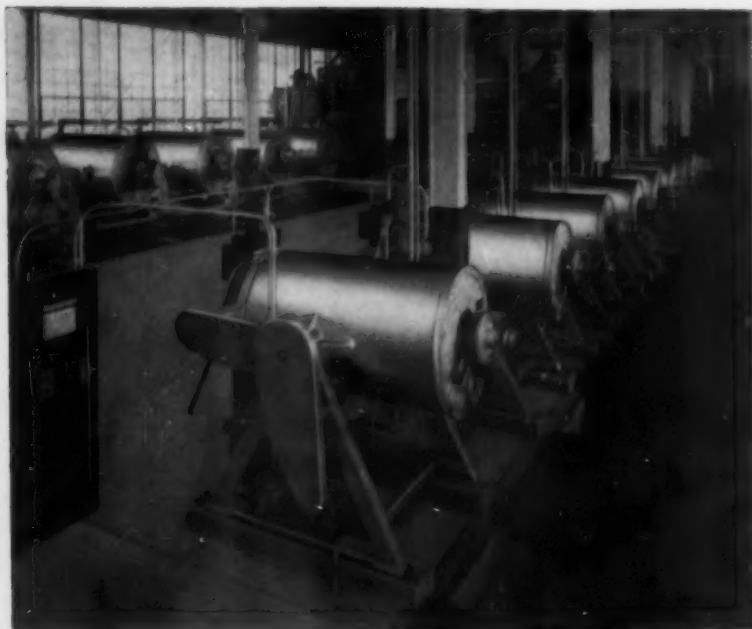
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## Stress-Relief . . .

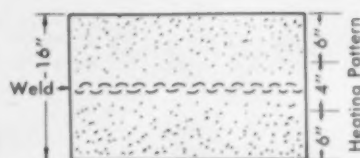


Fig. 1 — Longitudinal Welded Seam

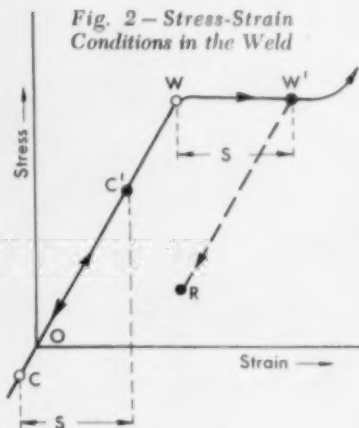


Fig. 2 — Stress-Strain Conditions in the Weld

respective positions on a stress-strain curve (Fig. 2) are at W (the yield point, or about 45,000 psi. for tank plate) and at C.

This piece of steel may now be strained an amount equal to S (Fig. 2) in a tensile machine; the metal in the outer strips is below the yield point, at C', and still in the elastic range. The central part of the weld, however, already at its yield point, stretches plastically and its condition is represented by point W'.

When the tensile load is relieved, the outer portions of this composite sample elastically contract to a condition near the origin O—that is to say, have practically no residual stress. Likewise, the overstrained center also contracts along a line parallel to the stress-strain curve, and winds up in a condition represented by point R—that is, with very little stress indeed when compared with its as-welded condition.

It follows from the above that it should be possible to relieve longitudinal stresses in welded joints if narrow strips on either side of the weld are expanded slightly by localized heating, either with a bank of electric resistors or by heating flames. If you make the further assumption that the outer 6-in. strips in compression balance the tension in the

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## Stress-Relief . . .

central 4-in. strip, one can compute that these outer strips should be heated to about 310° F. in order to relieve the stresses effectively at the center. This idea was widely used during World War II under the somewhat inaccurate name of "controlled low-temperature stress-relieving process". The equipment was a traversing device whereby two multiflame heads produced brush-like flames 6 in. wide which straddled the joint and moved uniformly along at sufficient speed to heat the metal to 350° F. It is important that the 4-in. wide central strip be

### Residual Stresses in Welded Tank

LOCATION	LONGITUDINAL		TRANSVERSE AFTER RELIEF
	BEFORE RELIEF	AFTER RELIEF	
Head seam	31,100 psi.	4,817	-3,108
Girth seam	36,700	-4,917	-1,275
Longitudinal seam	51,283	9,383	942
Intersection	35,350	1,100	-2,100

unheated, and therefore quenching heads, spraying the plate with water, follow 6 to 8 in. behind the advancing flames. Temperatures are checked by Tempilsticks—fusible crayons for 350, 400 and 450°—crossing the joint, inside, at short spacings. The 450° F. streak should never melt; the 400° F. for about 2 in. only in the thicker plate; the

350° F. should show two heat bands 5 in. wide. Speed of advance of heating flames is adjusted to the plate thickness: 24 in. per min. for 0.5-in. plate; 16 in. per min. for 0.75-in. plate; 10 in. per min. for 1-in.

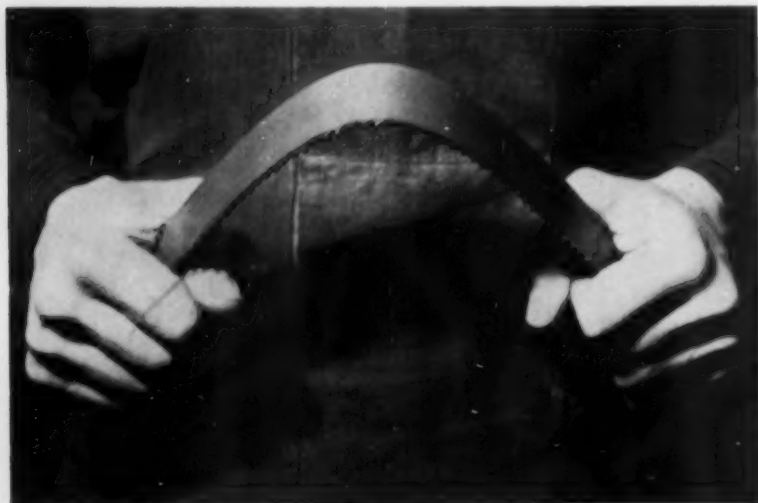
While this scheme proved successful for flat plates it was not until 1945 that an opportunity arrived to test it on three propane tanks, 8 ft. diameter, 50 ft. long, welded of 0.80-in. plate and with 1.06-in. dished heads, designed for 200 lb. working pressure. The steel was fire-box quality, A.S.T.M. specification A-212, with yield strength of about 42,500 psi.

SR-4 electric resistance strain gages were affixed at typical points at a head seam, a girth seam, a longitudinal seam, and at an intersection. Two gages were used both inside and outside; one was longitudinal to the weld, the other was transverse. Three-inch plugs containing these gages were then trepanned, and the locked-up stress at each location computed from the change in strain and the modulus of elasticity, using the equations for a two-dimensional stress system.

Next all three tanks were stress-relieved with traveling flames, as above recommended, and similar plugs trepanned at corresponding points, and from them the residual stresses were computed. Results from all three tanks were consistent. Averages are shown above (wherein— means compression).

Simultaneously, distortion due to flame relief was measured by gage marks and a mechanical gage accurate to less than 0.0001 in. per in., and it was found to be about one-third that expected to be caused by the 200-lb. working pressure.

Similar tests were made on 2.5 and 3.5-in. welded plugs. Strain relief by heating a circular band cut the maximum stresses on the order of 32,000 psi. in tension in both directions to an average of 8650 psi. in tension. The maximum compressive stress found in the heated strip around the plugs was 17,300 psi. ☉



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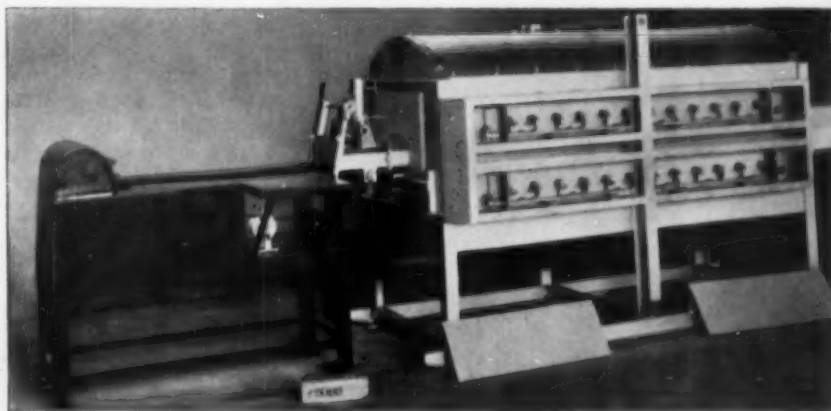
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## Current Research in the United States

Digest of "Trends in Metallurgical Research in the United States", by Edgar C. Bain, *Journal of the Iron and Steel Institute*, Vol. 181, November 1955, p. 193 to 212.

THE Eighth Hatfield Memorial Lecture before the British Iron and Steel Institute in October 1955 consisted of a broad review of research trends. American publications indicate an increasing preponderance of theoretical treatment accompanied by critical experiments to test these theories. Several examples are summarized.

A foremost development in X-ray diffraction technique is the replacement of photographic film by electronic counters, for more accurate intensity and angle measurements. X-ray diffraction is being used to measure elastic strain, particularly the difference of interplanar spacing of planes nearly parallel to the surface and a set of corresponding planes at about 45° to the surface. Diffusion penetration curves are being determined by absorption techniques. Neutron diffraction is useful in studying alloys made up of elements adjacent in the periodic table. A particularly useful technique for chemical analysis is X-ray spectroscopy, or fluorescence analysis.

Martensitic transformations have been studied in sodium and lithium. Current theories for the mechanism of the martensite-type transformation are (a) nucleation and growth, and (b) nucleation by strain embryo and propagation by a cooperative displacement of the austenite atoms. Attention is being paid to deformation of austenite induced by the volume change accompanying transformation in steel, and details of the orientation relationships in the transformation are being predicted theoretically.

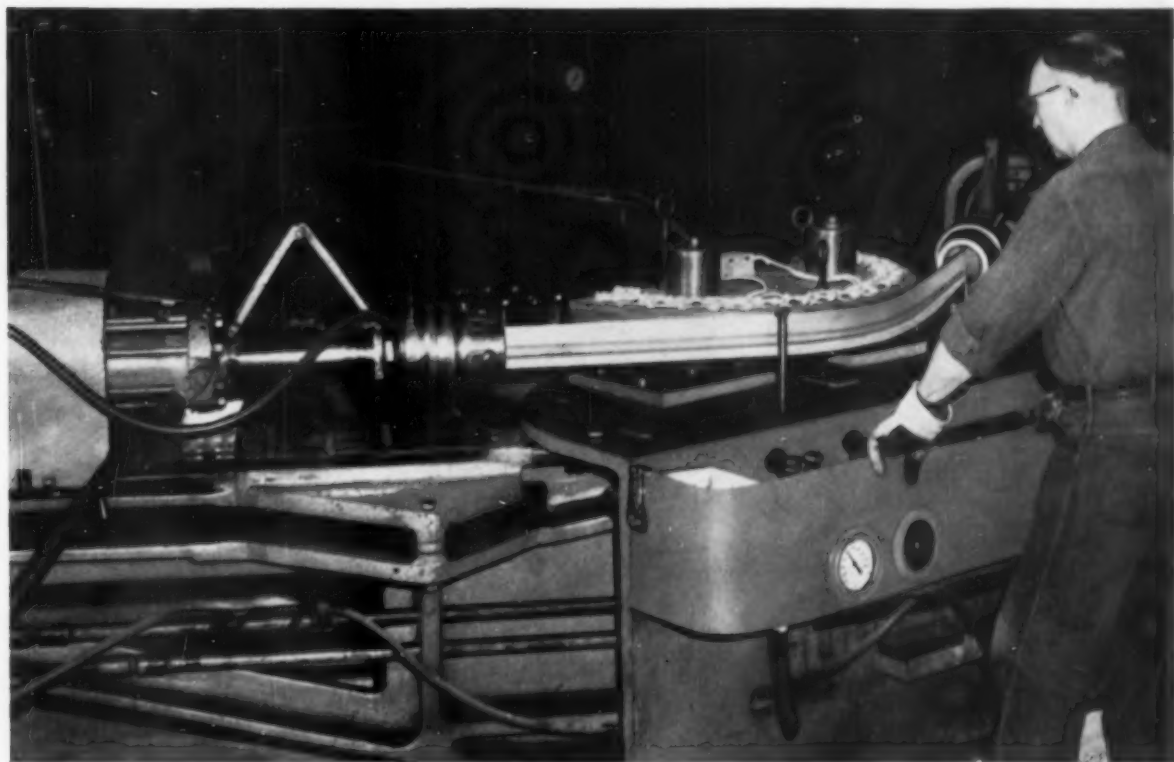
Reasonable unanimity exists in the details of the tempering of martensite. The four stages of tempering have been established on a firm basis by Cohen and co-workers, and by Jack. The much-discussed 500° F. embrittlement is thought to be caused by a more or less continuous cementite network around boundaries of martensite needles.

During World War II boron be-

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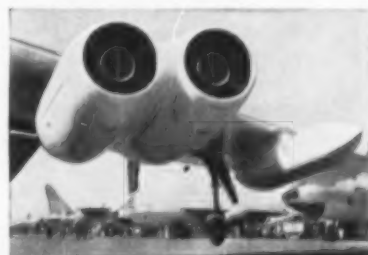
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nium heat, and further certify that 97.5% of the heat lies within narrow limits of this value (such as  $\pm 5000$  psi).

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## Research . . .

came an important auxiliary agent to enhance hardenability, but scientifically, the mechanism remains obscure. It has been found that boron delays the transformation in iron-boron alloys, and that boron can substitute for carbon in cementite to form boro-cementites.

In electron metallography a new extraction replica technique has a two-fold function: It provides a conventional replica of the topography of the etched surface, and it undermines and extracts particles of the segregate phase so that they will adhere to the replica on stripping. The electron microscope is being profitably used to study the bainite reaction. Electron emission microscopy has exciting potentialities in metallurgical research.

Nachtrieb has proposed an interesting theory for the diffusion mechanism called the "relaxed vacancy model". It involves the movement of a 12 to 14-atom region of disorder relaxed about a vacancy as in liquid metal structure. This theory predicts that the activation energy for self-diffusion is 16.5 times the latent heat of fusion.

The dislocation theory is being refined and made more useful. Critical experiments to test the theory include grain-boundary movement under stress, spacing of etch pits in grain boundaries, polygonization, spiral growth of crystals, and filamentary crystals.

Much information on fatigue mechanism is being deduced by making replicas of fatigue surfaces periodically during cycling, to yield permanent records of structural details. Six distinct stages of fatigue fracture are discernible.

In attempts to evolve fundamental factors which determine the machinability of a metal, it was found that sulphur acts to decrease friction between chip and tool and reduction of shear strain during chip formation.

A great deal of research is being conducted on the mechanism of brittle fracture and tests for evaluation of materials. Studies involving the actual individual grain behavior have been particularly fruitful.

Purification of metals by zone melting has become an important metallurgical technique, particularly

# FAHRALLOY...

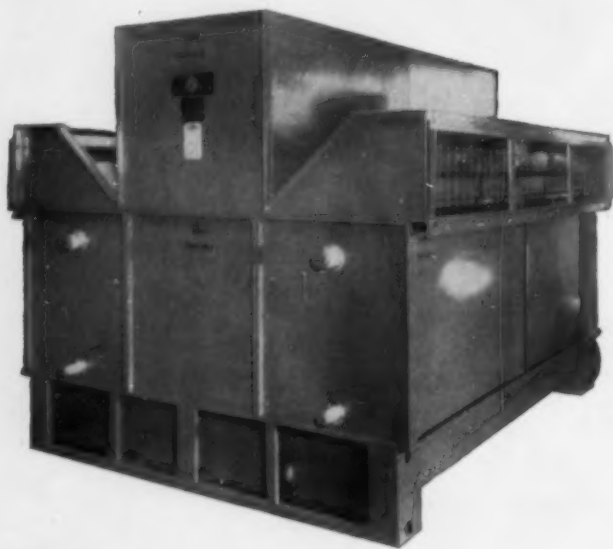
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## Research . . .

in the field of semiconductors; current efforts are toward the development of continuous zone melting.

Thermodynamic activity of components of alloys and compounds is being determined by gaseous equilibria, two-layer distribution, electromotive force, vapor pressure, by high-temperature galvanic cell, and by calorimetry.

Studies by Chipman and collaborators on the physical chemistry of steelmaking continue, including such subjects as free energy of compounds, deoxidation, and slag-metal studies. Definitive research is being done on hydrogen in liquid steel and slags.

J. W. SPRETNAK

## Oxidation Resistance of Aluminized Steel

Digest of "The Heat Resistance and Applications of Hot Dip Aluminized Steel", by M. L. Hughes and D. F. G. Thomas, *Metallurgia*, Vol. 52, November 1955, p. 241-245.

THE RESISTANCE of steel carburizing boxes and annealing covers to oxidation at high temperatures has been improved by cementation or spraying with aluminum, but dipping in molten aluminum is more convenient for sheet, strip and wire. A method developed by the British Iron and Steel Research Assoc. to prevent oxidation of the steel before dipping is to apply a thin film of either copper or glycerol. Glycerol is preferable because it burns to form a protective atmosphere.

Samples of coated sheets were heated for 2000 hr. in an open muffle furnace at temperatures between 930 and 1470° F. either in air or in air contaminated by a little sulphur dioxide. With 6% silicon in the aluminum the luster of the coating was maintained up to about 1100° F. Samples with cut edges gave erratic results because of scaling of the steel bared by the cut so most of the tests were made with specimens whose edges were coated. Specimens with sprayed coatings, some containing silicon or cadmium, were tested along with the hot dipped specimens.

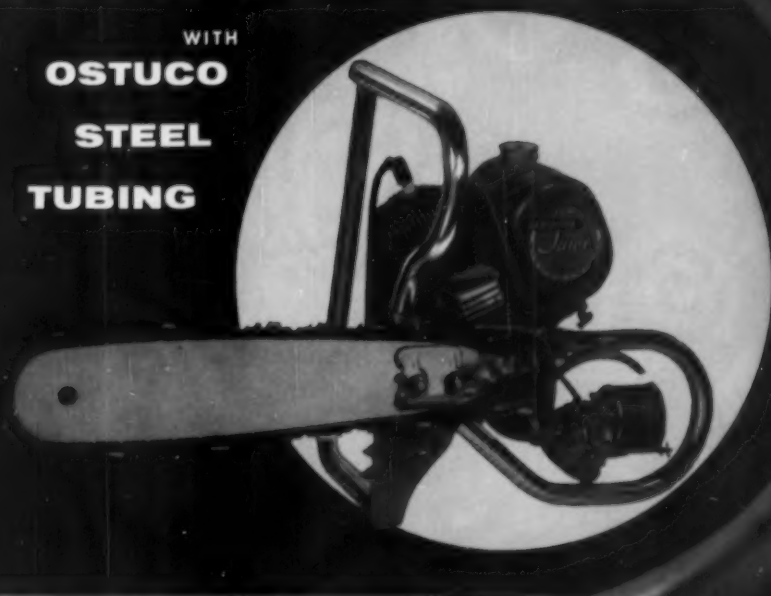
Results of 1600 to 2000-hr. tests in air at 1140, 1290 and 1470° F.

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## Aluminized Steel . . .

show that the dipped coatings of pure aluminum oxidized more slowly than those containing silicon and much more slowly than the sprayed coatings. After 1600 hr. at 1140° F. the aluminum dipped coatings gained about 0.4 mg. per sq.cm.; at 1290° F. about 0.7; and at 1470° F. about 7.5. The aluminum-silicon coatings gained about 1.6, 6 and 9.5 mg. per sq.cm. at the same temperatures and the sprayed coatings gained up to 4.5 mg. per sq.cm. at 1140° F. and up to 38 at 1290° F.

The tests in air contaminated by sulphur dioxide were made in a vertical tube furnace for 490 hr. The results at 1140 and 1290° F. were about the same as in uncontaminated air. At 1140° F., uncoated steel gained 12.5 mg. per sq.cm. in 490 hr.; the coated steel gained less than 1.5. At 1290° F., the gain was 213 for the uncoated and 1 to 3.9 for the coated samples. At 1470° F., the coated samples in air without sulphur dioxide gained 3.1 to 5.6 mg. per sq.cm. compared to 6.8 to 24 in the contaminated atmosphere.

Creep resistant steels can be aluminum-coated if strength at high temperature is required in addition to oxidation resistance. Tests by Socom Vacuum Oil Co. have shown that 18% Cr steel lost 17%, and 27% Cr steel lost 8.4% as scale when heated 24 hr. at 1350° F. in sulphur-bearing gases, and aluminized steel with 0 to 18% chromium lost only 0.1% in 192 hr. at the same temperature. Aluminized steel lost only 0.1 mg. per sq.cm. in 50 hr. exposure to hydrogen sulphide at 1110° F., while 18% Cr steel lost 55 to 90 mg. per sq.cm. under the same conditions. Stainless steel has been replaced successfully by hot dipped aluminized low-alloy steel in diesel engine exhaust manifolds and military tank heat exchangers for use at 900° F.

Thicker aluminum coatings give longer service but are more likely to spall with sudden changes of temperature. Heat treatment of the coated articles to promote diffusion decreases the spalling tendency but also reduces the heat resistance. Diffusion should not be allowed to reduce the aluminum content at the surface below 10%.

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## Grain-Boundary Creep in Aluminum

Digest of "Grain Boundary Creep in Aluminum Bicrystals", by F. N. Rhines, W. E. Bond and M. A. Kissel, © 1955 Preprint No. 14 (*Transactions, American Society for Metals*, Vol. 48, 1956, p. 919).

**W**HEN grain-boundary creep is measured parallel and transverse to the direction of load of aluminum bicrystals, entirely different results are obtained. The metal along the grain boundary which is parallel to the stress direction elongates in a regular manner. Such elongation is similar to that of the specimen as a whole, except at a slower rate. Transverse to the direction of load, however, the start of yielding is delayed until the termination of a more or less extended induction interval. Thereafter, shear resumes at the original fast rate, only to diminish to zero, and this continues in an irregular sequence of surges.

Bicrystals of 99.95% pure aluminum were oriented at 45° to the tension axis and perpendicular to the reference or observed surface. A reference pattern was photo-engraved upon the broad face of each specimen. At three points along the grain boundary the horizontal displacement of bisected squares was measured and averaged. Simultaneously, measurements were made of the elongation of each of the two crystals parallel to the stress axis. The vertical displacement along the grain boundary was also measured.

Measurements made parallel to the applied stress do not record the lateral displacement of one grain with respect to the other, as they would if grain-boundary displacement were a shear upon a single interface between the two grains. This can only indicate that the lateral displacement of grains is occurring in a layer of metal of known thickness. The layer is extending at a nearly constant rate in the stress direction, even though yielding transversely in a sequence of surges.

The direction of grain-boundary gliding is insensitive to the orientation of the adjacent crystals. Motion is always in the direction of the maximum shear stress resolved into the plane of the grain boundary. However, the relative orientation of



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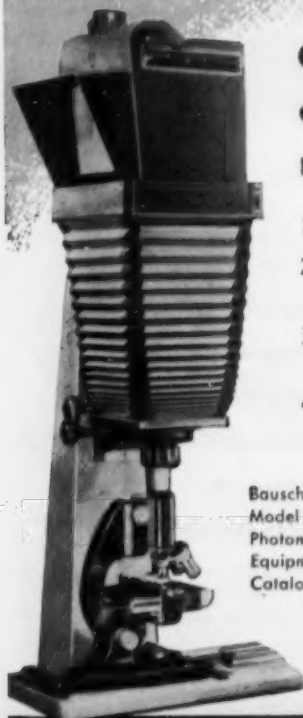
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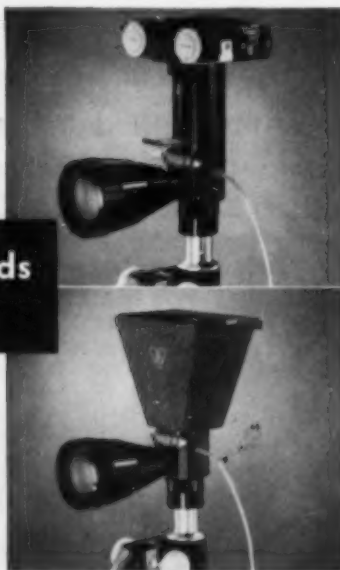
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## Grain-Boundary Creep . . .

the adjacent crystals exerts a profound influence upon the rate of gliding and this effect persists through many cycles of motion and rest despite considerable distortion of the metal in the grain boundary. The velocity of gliding increases with the sum of the angular difference between the operative slip directions in the adjacent crystals and the angular difference between the active slip planes as measured between their intersections with the grain boundary.

Gliding continues indefinitely in a sequence of cycles upon the same path, broadening more rapidly with greater time, temperature and stress. The active zone along the grain boundary is composed of subgrains that are rotated through larger angles than the subgrains of the body of the crystal. The direction of rotation reverses many times during a single cycle. Instead of the rupture occurring through the grain boundary, the failure is always transgranular.

During the induction period slip is presumed to cause a localized bending of the crystals all across the face of the grain boundary. When sufficient energy has been stored, recovery occurs by a process such as polygonization. The metal in the recovered zone now forms a continuous layer of material that is softer than the enclosing metal. Rapid yielding occurs along the grain boundary—the direction of minimum resistance to yielding.

Since the subgrains cannot remain identically oriented, the frequency of the slip-recovery cycle must differ. This causes some regions to be out of phase with other regions, whereby grain boundary gliding will slow down and stop.

In the rest interval that follows, the subgrains of the grain-boundary zone may behave much like those elsewhere within the crystals. They are subject to a reversing slip and recovery cycle, but locally, contributing only to yielding in the direction of the applied stress. In the absence of coordinated lateral yielding, bending energy will again accumulate along the grain boundary and, presently, coordinated recovery and yielding, parallel to the grain boundary, will be resumed.

F. N. RHINES

METAL PROGRESS



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## Diffusion in Metals

Digest of "Diffusion Short Circuits in Metals", by R. E. Hoffman, *General Electric Review*, March 1956, p. 28-31.

A DIFFERENCE in chemical composition within a material is similar to a difference in electric potential in an electronic circuit. A concentration gradient will lead to a flow of atoms that tends to reduce the gradient. The symbol  $D$  (diffusivity)

represents the proportionality constant between the gradient and the rate of atomic flow. The rate of diffusion is thousands or millions of times lower in solids than in liquids.

Dushman and Koller measured changes in electron emission and deduced the rate that thorium diffused to the external surface of thorium-tungsten filaments. At temperatures near 4000° F. this rate increased notably with decreasing grain size of the filament. This was interpreted as an indication that

thorium migrated primarily by grain-boundary diffusion. Langmuir later demonstrated that at temperatures near 4800° F. the rate of arrival of thorium at the surface was governed not by grain boundaries but by the rate of diffusion through the grains, or lattice diffusion. The grain-boundary diffusivity,  $D_b$ , and the lattice diffusivity,  $D_l$ , and their temperature dependence were calculated. These calculations showed that  $D_b$  is about 700 times larger than  $D_l$  for the diffusion of thorium through tungsten at 4400° F.

In 1948 a comprehensive investigation of self-diffusion in silver was conducted using radioactive silver. A thin layer of radioactive silver was electroplated onto one flat face of a silver cylinder and heated to 1400° F. for several days after which the radio-silver and a 0.002-in. layer of the cylinder were ground off. The radioactivity of the new surface was recorded on a photographic plate. It was revealed that the radioactivity corresponded with the grain boundaries in the silver indicating that radio-silver diffused more rapidly along the boundaries. Different intensities of radioactivity indicated that the diffusion rate was not uniform in the grain boundaries. Current theories indicate that you can expect dislocations or regular spaced regions of disorder when the angle of misorientation is small. Quantitative measurements of the distribution of the isotope in samples having a controlled orientation confirmed these theories and showed that rapid diffusion occurs only in that fraction of the boundary occupied by dislocations.

The lattice diffusion coefficient  $D_l$  was determined in large single crystals of silver. These data yielded values of the ratio  $D_b$  to  $D_l$  varying from  $10^4$  near the melting point of silver to  $10^{18}$  near room temperature. The magnitude of these numbers demonstrates the ability of grain boundaries to act as diffusion short circuits.

Grain-boundary diffusion has practical effects. At temperatures high enough for diffusion to occur at a significant rate, the average grain size spontaneously increases. The steps in this process are believed to be (a) dissociation of atoms of a lattice, (b) migration across the boundary and (c) attachment of atoms to the lattice of an adjacent

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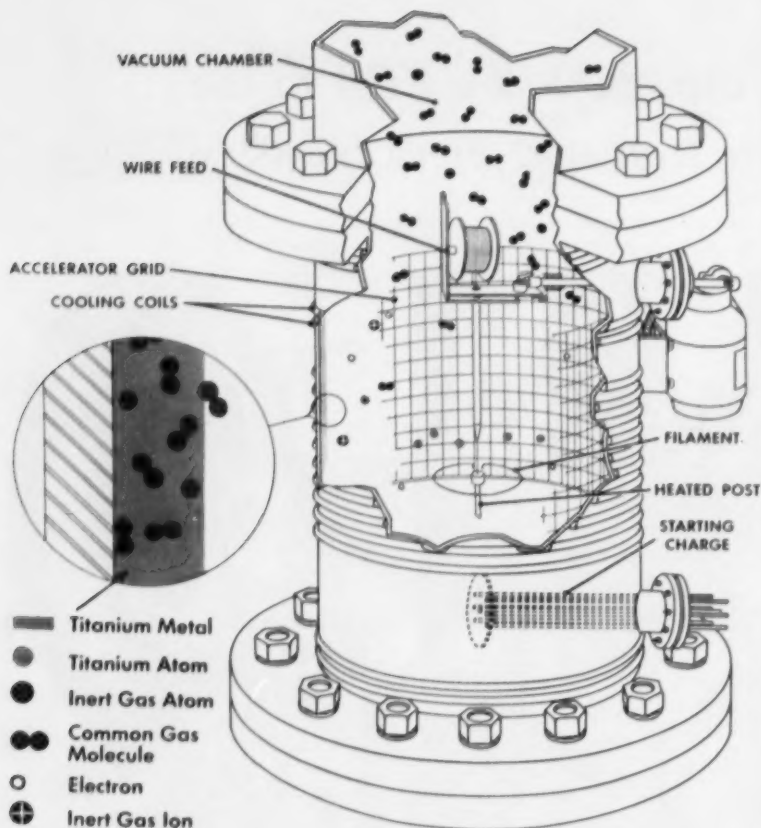
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## Diffusion . . .

grain. Grain-boundary diffusion becomes one of the factors that determine the rate of grain growth.

Diffusion rates also appear to control the precipitation rate in age hardenable alloys. In some alloys the observed rate nearly agrees with the known lattice diffusion rates while in others the precipitation rates, calculated from lattice diffusion rates, are millions of times slower than those actually observed. This mechanism is dependent upon grain-boundary diffusion whereby  $D_b$  can be millions of times larger than  $D_l$ .

Sintering of powder metal also appears to depend upon grain-boundary diffusion. Ideal densities are present along boundaries while the interiors of the grains remain porous.

Grain-boundary migration during high-temperature service can hasten failure. Readily oxidizable alloys coated for protection fail when the protective coating diffuses into the base metal. The effects of grain-boundary diffusion must be minimized if maximum service is to be obtained from these materials.

ROBERT F. HARTMANN

## Corrosion of Bearings and Valves

Digest of "Corrosion in the Motor Car: No. 4. Bearings and Exhaust Valves", by Z. S. Michalewicz, *Corrosion Technology*, Vol. 2, November 1955, p. 334-338.

**B**EARINGS and exhaust valves, vital components of internal combustion engines, operate under conditions favoring corrosive attack. How to minimize these conditions for bearings is made more difficult by the trend toward higher power, and for valves by the use of gasolines containing tetra-ethyl lead.

Corrosion resistance is but one requirement of a bearing; others include load-carrying capacity, fatigue resistance, conformability and embeddability, thermal conductivity, wear rate and economy. However, considering the problem of corrosion alone, the chief cause is considered to be excessive engine temperature which causes oxidation of the lubri-

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## Corrosion . . .

cant and formation of corrosive peroxides and organic acids. Beginning at a temperature of 230 to 250° F., the rate of corrosion in terms of weight loss may double with each 5° temperature rise above the critical temperature. This emphasizes the importance of choosing the correct type and quality of lubricant for a specific service.

A special type of corrosion has been observed with excessively long oil drain intervals or when using oils providing less than the minimum protection. It has been termed pressure corrosion since it is restricted to areas of highest pressure and, consequently, temperature. Ends and edges of the bearing usually remain unattacked.

Principal types of bearing metals include tin-base and lead-base babbitts, cadmium alloys (with small amounts of nickel or silver and copper), copper-lead alloys, silver, bronzes, alkali-hardened lead, aluminum alloys and "gridded" or compressed and impregnated powdered copper-nickel alloys.

The century-old babbitts satisfy most bearing requirements, except that load capacity and fatigue resistance are rather low. Unalloyed lead is attacked strongly by oxidized oil, so lead-base babbitts contain additions such as tin and antimony. The tin-base babbitts have better resistance and are used in the majority of passenger car engines in Great Britain.

Cadmium alloys have higher strength and better high-temperature properties but are sensitive to corrosion. To prevent such corrosion, indium is plated on the bearing and diffused into the surface.

Copper-lead alloys (25 to 40% lead) are in wide usage because of higher load capacity. Copper and lead form two separate and independent phases in the alloys, leading to preferential corrosion attack on the lead unless it is protected by plating, such as with 0.001 to 0.002 in. of lead and tin; lead, tin and copper; or lead and indium. A thin nickel dam is usually deposited over the copper-lead alloy before the protective overlay, to prevent diffusion of the tin.

High cost of silver precludes its general selection despite advantages

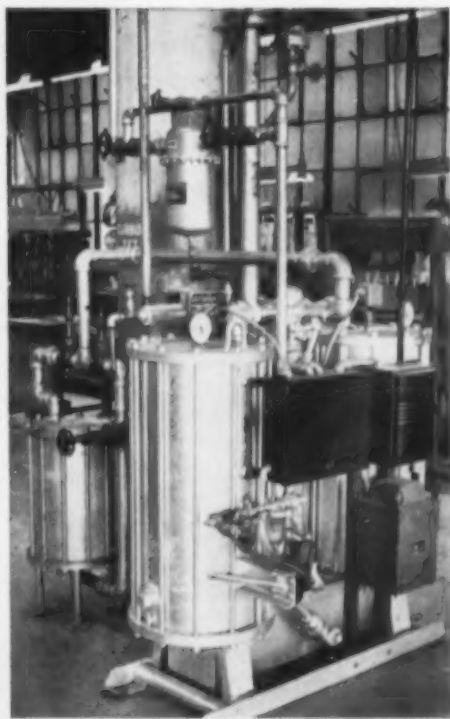
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## Corrosion . . .

in heavily loaded bearings. An overlay of 0.001 in., similar to that on copper-lead, usually is applied to silver.

Poor antifrictional properties of bronzes preclude their use although addition of 25% lead improves them. Hardened lead containing a little tin and small amounts of hardening elements like calcium, aluminum

and magnesium, has found favor in Germany although corrosion resistance is not good. Aluminum alloy bearings have shown considerable popularity in the U.S. Both solid and bonded to steel backing, these alloys are highly resistant to corrosive attack in engines.

Since about one third of the thermal energy generated in an engine cylinder—about the same amount usefully employed for propulsion of the vehicle—is rejected as waste

heat in exhaust gases, exhaust valves obviously are subject to intense oxidation attack. Temperatures of valves at hot spots may reach 1400° F. in passenger-car engines and 1600° F. in trucks. "Cold" corrosion is also encountered, resulting from formation of acids from certain products of combustion and water vapor condensing in the cylinder. It is not a significant factor, however, when valves are of corrosion resistant steels protected by effective lubricants.

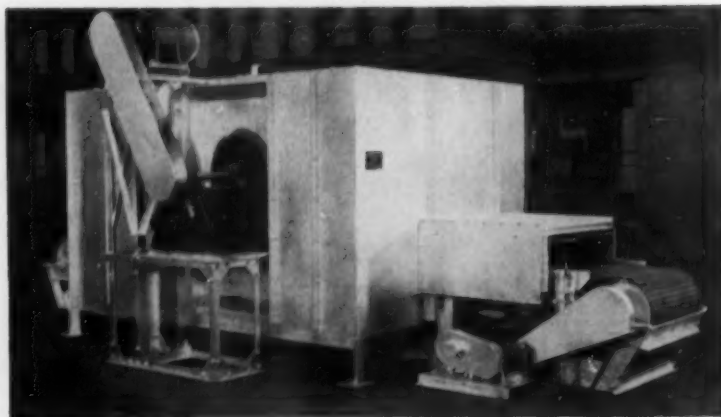
All good exhaust-valve steels develop continuous protective oxide layers. The effect of hot corrosion is to disrupt this film at high temperature under the action of contaminated atmospheres. It is aggravated by leaded fuels. In the effort to prevent the formation of lead oxide from decomposition of tetra-ethyl lead during the combustion process, ethylene dibromide and ethylene dichloride are added to fuels to produce lead bromide and lead chloride which are volatile at high temperature. This promotes a scavenging action but it is seldom complete and a certain amount of lead oxide in exhaust gases is inevitable.

Above a certain temperature, lead oxide attaches itself to the valve surface and builds up deposits. At still higher temperatures the accumulated lead oxide fuses with the valve steel oxide. This destroys the protective film and promotes further oxidation by the lead oxide which acts as an oxygen carrier.

Most valve corrosion failures are caused by an attack on the valve seating face which starts with the development of a leak between the valve and its seat. Such leaks may result from small-scale corrosion pitting of the valve face or seat due to direct attack or to the molten lead oxide deposits moving across the valve head and reaching the valve face. The resultant leakage of hot gases raises the temperature of the valve head, sometimes by as much as 300 to 400° F., thus accelerating the progress of the attack.

Best safeguard against valve corrosion lies in selection of a suitable valve steel. These materials can be classified into three principal groups. First are the ferritic (Silcrome) steels, hardenable by heat treatment and relatively easy to form and finish. Second are the austenitic Silcromes, somewhat more difficult to manufacture and hardenable only

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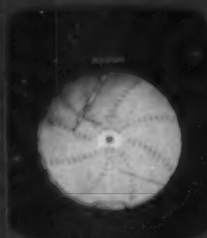
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## DYNALOG

ELECTRONIC  INSTRUMENTS

## Corrosion . . .

by mechanical work. They have good corrosion resistance and superior high-temperature properties. Third are the "sigma-precipitate" steels — austenitic Silcromes which can be precipitation hardened. The latter group of alloys is widely used in the U.S. although not so generally in Britain.

Where exceptional corrosion resistance and high-temperature properties are required, alloys such as Nimonic and Inconel are selected but cost is too high and manufacturing difficult. Hard facing of valve seats and occasionally of the entire

head is frequently employed for heavy-duty engines.

Development of a technique for producing a tightly bonded coating of aluminum on steel valves has resulted in superior corrosion resistance and such valves are in production for passenger cars in the U.S.

The metallurgist may feel he has licked the valve corrosion problem by development of suitable alloys, but he will fail without the cooperation of engineers responsible for details of valve design. They include factors such as size of head and stem, size and position of guides, shape of exhaust ports, cooling water passages, use of valve rotators and seat inserts. **ARTHUR H. ALLEN**

## Automatic Sonic Inspection of Castings

Digest of "The Utilization of Sonic Principles for Application to an Automatic Method of Casting Inspection", by Milton J. Diamond, *General Motors Engineering Journal*, Vol. 3, No. 2, March-April 1956, p. 38-42.

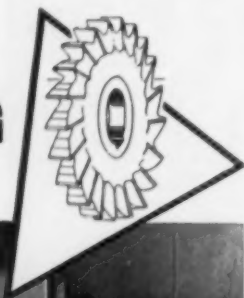
**S**ONIC TESTING for identifying internal defects by striking the suspended casting and noting the resultant ring has been in use for a long time. Very little progress, if any, has been made in its instrumentation. The difference in vibration frequency between a good and defective casting is in the audible range; however, any method dependent upon the human element is sure to have its limitations.

Other nondestructive testing methods for castings are the Magnaflux and fluorescent particle techniques. These tests also depend upon the human element and often lead to false indications of defects by recording small folds in the casting skin as cracks. Such small folds are later machined off by the user.

Engineers at the Central Foundry Division of General Motors Corp. put the sonic inspection test of production castings on an automatic basis. Previously tested good and defective castings of identical shape, weight, hardness and chemical analysis were selected for frequency measurements after being struck. The purpose was to determine accurately whether good and defective castings had frequency ranges of vibration that differed and whether there was sufficient spread in the frequency to classify good and bad parts.

Instrumentation for the basic tests consisted of a crystal-type

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A recent national survey of high speed steel tool manufacturers (making items similar to the milling cutter shown above) indicates that much time is wasted in grinding tools after hardening.

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Block atmosphere, tools may be soaked to assure maximum hardness characteristics and come from the high heat absolutely free from scale or decarburization. Sharp cutting edges are faithfully maintained and little or no finishing operations are required.

You too can save with Sentry quality controlled hardening on all grades of high speed and high carbon, high chrome steel. Consult Sentry for a demonstration on samples of your own tools.



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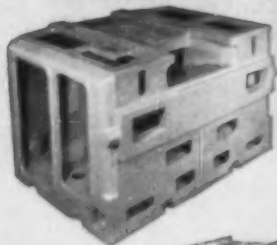
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**QUALITY  
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## Inspection . . .

"pickup" transducer, a pre-amplifier, an oscilloscope and an audio oscillator. The specimens of small cast crankshafts were shocked into vibration by a leather mallet. Vibrations were picked up by the transducer and amplified. Output of the pre-amplifier was fed to the horizontal plates while output of the audio amplifier was fed to the vertical plates of the oscilloscope.

The casting was shocked continuously so its vibration frequency pattern could be transmitted to the oscilloscope screen. The audio oscillator was tuned until its frequency pattern and that of the casting formed a single elliptical shape on the screen — referred to as a *Lissajous* figure. This is the result of a combination of two simple harmonic motions when sinusoidal voltages are applied to both plates of the oscilloscope. Vibration frequency of the casting was read from the calibrated dial of the audio oscillator.

Further tests on certain types of castings showed that frequency separation of good and defective pieces could be increased by using harmonics of the fundamental frequencies. In some instances it was necessary to find the proper method of suspending a casting so desirable frequency separation could be obtained. For example, a brake pedal casting gave desirable separation (between good and defective parts) on only one of three possible positions of suspension.

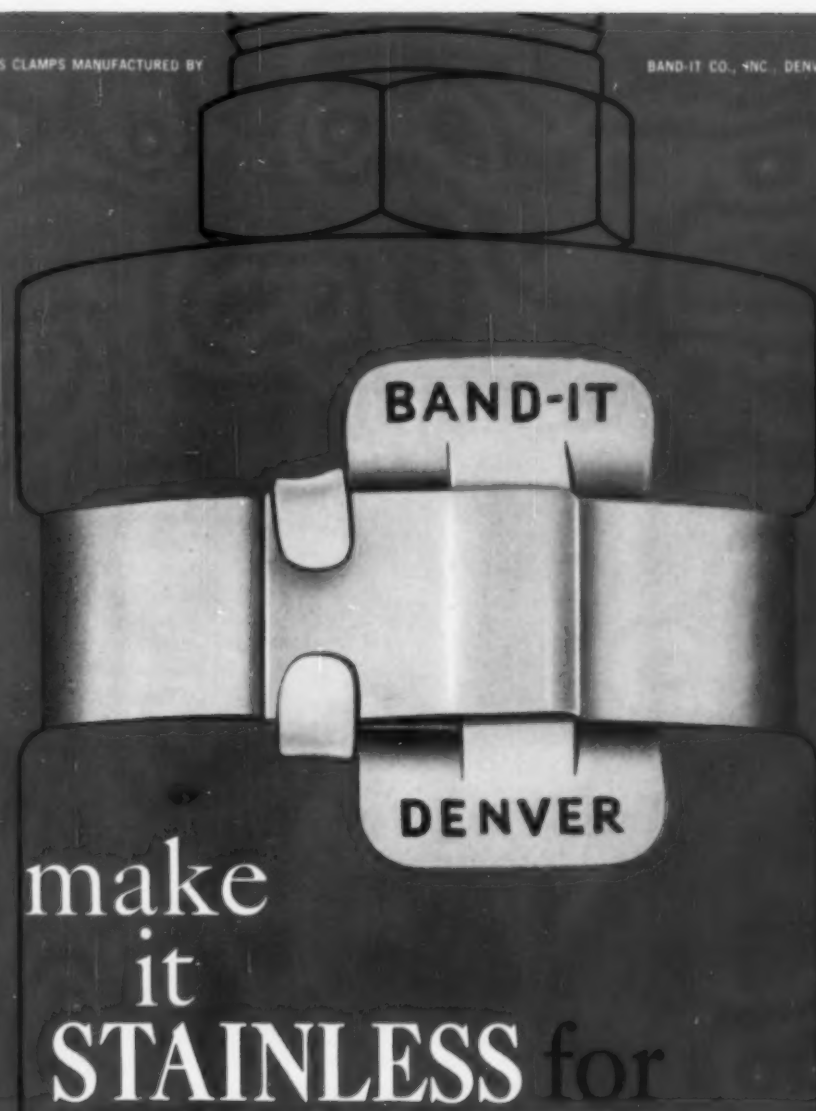
A machine was developed to combine instrumentation and handling automatically so good castings would be painted and accepted while the bad were rejected. A universal-joint slip yoke casting was selected for testing since it required a high standard of inspection.

Refinements were necessary in the heart of the electronic control system. The heart or "discriminator" is extremely sensitive to a very few cycles change in frequency. Actually, two discriminators were ultimately needed — one each for the high and low end of the frequency range. In addition, a limiting amplifier, a pre-amplifier and a specially designed microphone pickup were included in the control section of the machine.

Final design of the production apparatus used the "merry-go-round"

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## Inspection . . .

principle with four work stations 90° apart. Specially constructed holders gripped the casting as it passed through each station. Three types of slip yokes could be handled with only minor adjustments.

At the loading station of the machine, an operator places a casting into a guide. A cam-operated clamping device passes by the guide and

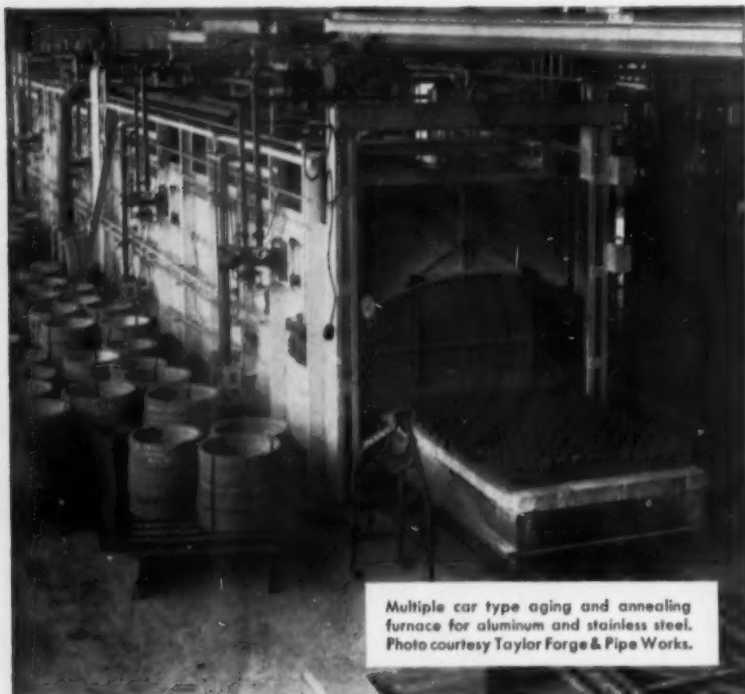
grips the casting to move it to the ringing station. Here a small steel ball welded to the end of a rod is pneumatically actuated and strikes the casting. Resulting vibration travels across a ½-in. air gap and is picked up by a dynamic-type microphone having special focal properties. The impulse is sent through the pre-amplifier, limiting amplifier and finally to the two discriminators which channel the frequency into the proper range.

Polarized relays in the discriminators are interconnected so when the casting's vibration frequency is within the "good casting" range, a latch relay operates to accept the casting at the "good unload" station. Here the casting is automatically sprayed with paint and dropped onto a conveyor for transfer to a hopper. If the frequency does not fall within the "good" range, the latch relay does not function. The casting passes by the "good unload" station and is released to fall onto a conveyor for transfer to a rejected casting hopper.

With the increased use of the shell molding process of making castings and its accompanying closer tolerances, wider application of sonic testing can be anticipated. Castings that have been inspected in this manner include brake pedals, jack hooks for bumper jacks, automatic transmission gear cases, gear blanks and smaller-size crankshafts.

The mechanized sonic inspection installation has resulted in material savings and increased production. Testing by this method has given the customer a higher-quality casting, free of internal as well as surface defects which hitherto could only be discovered by the use of X-ray inspection equipment.

ARTHUR H. ALLEN



Multiple car type aging and annealing furnace for aluminum and stainless steel. Photo courtesy Taylor Forge & Pipe Works.

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## High-Temperature Alloys for Jet-Engine Buckets

Digest of "Wrought Jet Engine Bucket Alloys", by Stephen G. Demirjian, presented at Detroit Technical Meeting of Society of Automotive Engineers, January 1956.

COBALT-BASE and nickel-base alloys are largely used for the manufacture of buckets for jet engines because they are able to withstand high temperatures. General Electric Co. is investigating one cobalt-base (S-816) and three nickel-base alloys (M-252, Udimet 500 and Inco 700) principally to determine whether modifications in composition of the nickel-base alloys can yield even better properties. Although the investigations are not complete they have indicated the following differences in the mechanical properties of the four alloys. The results are based on tests of one heat of each alloy. (Continued on p. 200)



# Tool Steel Topics



On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Department  
Bethlehem Steel Company

## Airplane Builder's Change to Bearcat Increases Life of Rivet Sets 5 Times

At the Wichita, Kans., plant of Boeing Airplane Company, rivet sets used on the B-47 and B-52, as well as other types of aircraft, had been providing satisfactory results. But, Boeing engineers reasoned, by checking the performance of other grades of tool steel in the same application, they might discover a tool steel that could do a better, more economical job.

So they ordered Bearcat, from Ford Steel Company, their Bethlehem tool-steel distributor in St. Louis. The results were impressive. The Bearcat sets gave five times longer service life than the sets previously used. In addition, the heads also drove down better, thus minimizing time lost in reworking, and facilitating ready acceptance by Boeing inspectors. Besides, with Bearcat's superior finish, there was less surface pick-up.

Bearcat is our super-tough, air-hardening general-purpose grade. It has exceptional resistance both to shock and to wear. Its air-hardening characteristic minimizes quenching hazards, and provides excellent resistance to distortion in heat-treatment.

In addition to rivet-set applications, Bearcat can be used advantageously for punches, chisels, hot headers, gripper dies and master hobs, as well as for dies used in blanking and bending, and cold-forming.

If you'd like to know more about Bearcat, or perhaps try it out in your shop, just get in touch with the nearest Bethlehem tool-steel distributor.



### BETHLEHEM TOOL STEEL ENGINEER ASKS: How Hard Should Tools Be?

It is sometimes difficult to determine the best hardness for certain tools. As all tools are subjected to wear it is ordinarily desirable to use the highest possible hardness. With most tools, this causes brittleness or breakage, making some compromise necessary. Generally speaking, tool hardness should be lowered from the maximum to a degree which causes the tools to consistently wear out in service, rather than fracture. The optimum hardness for a given type of tool often varies considerably, depending upon the operating conditions. However, here are the average hardnesses of commonly used tools:

TOOL	HARDNESS ROCKWELL C
High speed steel, metal-cutting tools, single point	65
High speed steel, metal-cutting tools, multiple point	63
Blanking dies	60
Forming dies	60
Drawing dies, hardened all over	60
Drawing dies, bore-hardened only	66
Gages	60
Shock resisting tools (punches, etc.)	58
Hot-work tools	40/50
Cold shear blades	60
Hot shear blades	48
Tools subjected to max tensile loads (cylinders, containers, etc.)	53
Tools subjected to max compressive loads (plungers, punches, etc.)	60/65

These hardness figures should be used as a guide only, because for individual jobs the required hardness may be slightly higher or lower, depending upon circumstances.

## Tool Steel Color Film An Award Winner

"Teamwork," Bethlehem's 16-mm color film on tool steel, received an award for excellence in the sales promotion field at the recent Columbus Film Festival, held at Columbus, Ohio. The film, being received enthusiastically in all parts of the country, shows the manufacture of Bethlehem tool steels, and explains the reasons behind their quality control and heat-treatment. Typical applications of various grades are included.

The picture runs for 30 minutes. It is available for showings to machinists, die-makers, heat-treaters, machine-tool manufacturers and distributors. Its subject matter makes it excellent for technical society meetings, and for showings to engineering-student groups.

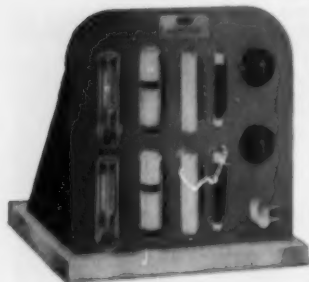
If you would like to see "Teamwork," drop a line to Publications Department, Room 1001, Bethlehem Steel Company, Bethlehem, Pa. If possible, please select a showing date well in advance, to permit adequate time for scheduling and shipping.

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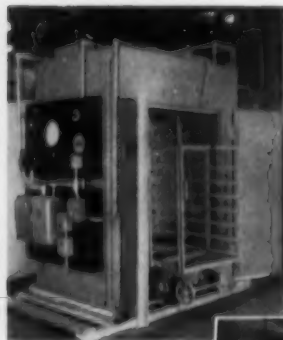
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*Ask for Bulletin No. 323*

**BURRELL CORPORATION**  
Scientific Apparatus and Laboratory Supplies  
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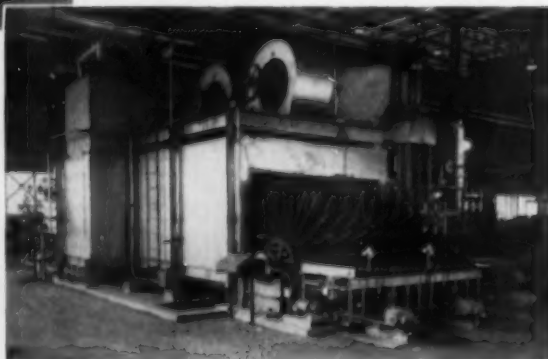
Standard truck type oven with complete control of temperature, heat input and power and air supply shut-off.

Continuous conveyor oven for automatic loading, annealing, cooling and discharging aluminum sheets; radiant tube gas-fired.

These are typical of many Rockwell recirculating ovens—standard or special—batch or continuous—electric, gas, oil or steam—engineered for top operating quality and economy.

Select a Rockwell oven with confidence that it will give you the right answer to your baking, drying or heat treating problem. Write for complete information.

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## Jet-Engine Alloys . . .

The tensile strength of the nickel-base alloys was greater than that of S-816 between 1000 and 1700° F.; however, S-816 was strongest at 2000 and 2100° F. Nickel-base alloys had lowest elongation and reduction of area in the temperature range of 1000 to 1600° F. but S-816 has lowest values at 1800 to 2100° F.

Since all four alloys are subject to grain growth, they must be forged under closely controlled temperature conditions. Here S-816 has the advantage since it has a forging range of 500° F., starting at 2100° F. and finishing at 1600° F. In contrast, M-252 has a forging range of 250° F., finish temperature of 1750° F.; Udimet 500 has a 100° range, finish of 1900° F.; and Inco 700 has a 200° range, finish at 1800° F. Attempts to increase the forging range of the nickel-base alloys resulted in severe rupturing of the buckets.

Another disadvantage of the nickel-base alloys is their susceptibility to a superficial intergranular attack at the high temperatures used for forging and heat treating. Such surface attack can be removed by electrolytic acid pickling, which will also remove any cold worked surface which may result from grinding. Either of these conditions can result in premature bucket failure should the pickling operation be omitted.

The conventional arc melting process is employed on Inco 700 and S-816 whereas M-252 and Udimet 500 are generally melted by the vacuum induction process. M-252 has been vacuum melted using the consumable electrode process. As compared to air melting on M-252, vacuum melting showed superior mechanical properties but more work is necessary to standardize the values. From this it may be assumed that vacuum melting of Inco 700 should be superior to air melting.

At present most buckets are manufactured by precision forging, which is done in five steps:

1. Cut slugs from centerless ground bar stock with an abrasive wheel.

2. Heat slugs by induction and upset to gather a volume of metal large enough to fill the hose section of the bucket. (Cont. on p. 202)

Tools made of modern

# High Speed Steels



and will do thousands of  
cutting and forming operations  
more economically than carbides

next time specify tools made of High Speed Steels

—and for first quality High Speed Steels  
remember these brand names:

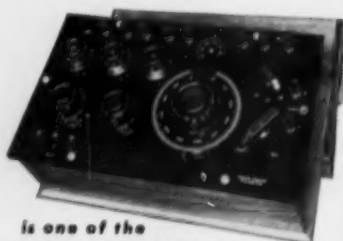
- |                    |                   |
|--------------------|-------------------|
| • Vasco Supreme    | • Neatro          |
| • Vasco M-2        | • Van-Lom         |
| • S-N-3            | • Van Cut         |
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is one of the  
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**TYPE B HIGH PRECISION  
POTENTIOMETER**

...a general purpose potentiometer with a number of notable refinements, suiting it particularly to thermocouple work. Distinctive features include:

- Three ranges—0 to 16 millivolts, 0 to 160 millivolts and 0 to 1.6 volts.
- Three reading dials—effective scale length of approximately 175 feet for each range.
- Subpanel switch and slidewire construction for protection of contacts from dust and corrosive fumes.
- Special provisions to minimize parasitic thermal emf's—including automatic compensation of slidewire thermals and gold contacts in galvanometer key.
- Exceptional convenience in reading and adjustment.
- Solid and substantial construction for many years of trouble-free service.

This standard laboratory potentiometer is also well suited for meter calibration, for checking portable potentiometers, and for other critical measurements of D.C. potentials requiring exceptionally high accuracy.

Described in Bulletin 270



**SPOTLIGHT GALVANOMETER  
FOR SHOP AND LABORATORY WORK**

- Sturdy, short period
- Sensitive (up to 1.5  $\mu$ V per mm.)
- Multiple-reflection optical system
- 100-Millimeter scale
- For null or deflection measurements

Described in Bulletin 320

## RUBICON COMPANY

Electrical Instrument Makers  
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## Jet-Engine Alloys . . .

3. Block using either a press or a steam hammer.

4. Finish.

5. Heat transfer.

The buckets are then subjected to a solution and aging treatment for maximum mechanical properties. When buckets are forged in this manner the concave surface receives more work than the convex surface. Roll forging is being investigated as a method of producing a superior product with less flash.

BERNARD TROCK

## Gas Turbines for Industry

Digest of "Industrial Gas Turbines—Past, Present and Future", by G. R. Fusner, *General Electric Review*, March 1956, p. 49.

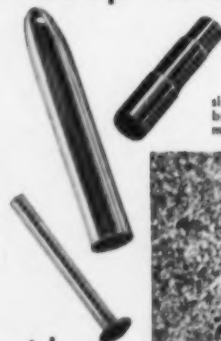
GENERAL Electric Co. made its first industrial gas turbine as late as eight years ago in an experimental locomotive. This was such a success that the Union Pacific Railroad now has 25 of them hauling heavy and fast freight trains over the Rocky Mountain divisions between Cheyenne, Wyo., and Ogden, Utah. These locomotives are rated at 8500 hp. at the worst air-intake conditions (low atmospheric pressures at 6000-ft. altitude and warm temperatures at 90° F.). Each tender carries 24,000 gal. of treated residual fuel oil. Operating costs for fuel, lubricants and maintenance per gross ton-mile for gas turbines and diesels are comparable (respectively 0.0394 and 0.0419¢).

Extensive cooperative tests by the American railroads and coal industry on a turbine fired with pulverized coal have been under way for several years. Here the problems due to fly ash are yet to be solved.

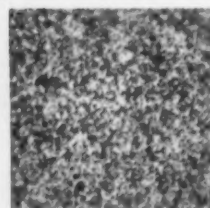
Treatment of such oil was early found to be a necessity to avoid rapid erosion of turbine blades and vanes. In fact, severe troubles were developing in steam plants, fired by similar oil; superheater parts and especially uncooled hangers were deteriorating when operating temperatures were increased. It was found that the ash from such oil

## Somers UNIGRAIN®

thin strip brass  
for  
deep drawing



Uniform fine grain  
size of Somers ayelet  
brass—less than .010  
mm. (75X).



with  
**Fine Grain Finish**

Typical of the modern equipment with which Somers is able to meet the most exacting requirements for thin strip metals is the continuous annealing furnace developed in cooperation with the Selas Corp. of America.

This unique process makes possible the deep drawing of Somers THIN STRIP brass to full 40% elongation while maintaining a uniform fine grain of less than .010 mm. which can be easily buffed to a brilliant finish.

And the Selas Furnace provides high production as well as close control of temper and uniformity. It is typical of the modern equipment with which Somers produces copper, brass and other alloys to rigid specifications between .010" and .00075".

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## Gas Turbines . . .

contained small amounts of  $V_2O_5$  and  $Na_2SO_4$ , which deposited on the metal and reacted with it when temperatures got high enough. If an industrial grade of  $Mg_2SO_4$  is added either at the refinery or by the user, it prevents in some way the deposition of this ash and so protects, indirectly, the heat resistant metal in burner liners and other high-temperature parts.

The largest use of G.E. gas turbines has been to operate booster pumps on oil and gas pipe lines. Here the fuel is at hand. Units of 3000 hp. are shipped complete as one package, mounted on a structural steel foundation which also forms the necessary lubricating oil and water tanks. Installation costs are therefore very low. Another advantage is that the turbine delivers more power when air intake temperatures are low—that is to say, in winter weather when the demand

for natural gas is at highest peak.

In the process industries the gas turbine is used primarily for an air compressor, either driving one directly, or bleeding air from its own compressor. It is especially suitable when the hot discharge gases can be used in evaporators or dryers.

A most interesting future possibility is as an auxiliary for steam-electric or hydro-electric systems, either in central stations or at isolated terminals. The gas turbine using either oil or gas as fuel, interchangeably, can start generating power with practically no warm-up, so it can promptly enter the system to care for a peak load or a sudden storm or other emergency. In a more humble capacity it is operating boiler feed-water pumps—usually the first bottleneck when capacity of an existing steam station must be increased. The exhaust of the gas turbine can help heat this feed water, or go direct to the steam boiler. Representative gains are quoted by the author: Addition of two 3700-kw. gas turbines "increased the capability of the central station by 14,000 kw. and reduced the 'station heat rate' 2.5%".

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## Welding Nickel Alloys

Digest of "Nickel and High-Nickel Alloys for Pressure Vessels", by R. M. Wilson, Jr. and W. F. Burchfield, *Welding Journal*, Vol. 35, January 1956, p. 32s-38s.

NICKEL and high-nickel alloys are being used for pressure vessels where pressure, temperature and corrosion resistance requirements are high. The authors have summarized information on the mechanical properties and welding and heat treating behavior of commercially pure nickel, low-carbon nickel, Monel, Inconel, Hastelloy B, Hastelloy C, "K" Monel and Inconel "X". All the alloys are recognized by the A.S.M.E. Pressure Vessel Code except the two age hardening alloys "K" Monel and Inconel "X", which may come into commercial use as operating temperatures and pressures increase.

Mechanical properties of the alloys are presented in a set of 22 charts from which the maximum allowable stress values in tension were determined at elevated temperatures. The

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## Welding Nickel . . .

maximum stress values were calculated in accordance with the A.S.M.E. Boiler and Pressure Vessel Code, 1952, Section VIII — "Unfired Pressure Vessels" as the lowest of the following:

1. One-fourth of the minimum tensile strength.
2. Two-thirds of the the minimum yield strength.
3. The stress producing a secondary creep rate of 0.1% in 10,000 hr.
4. Four-fifths of the stress producing rupture in 100,000 hr.

For bolting materials, one-fifth of the tensile strength and one-fourth of the yield strength are used.

The maximum allowable design stress is usually determined by the tensile or yield strength at temperatures up to about 900° F. and by creep strength above 900° F.

Nickel and the high-nickel alloys can be joined by all the welding processes normally used for steel pressure vessels without preheating or postheating. The age hardenable alloys, "K" Monel and Inconel "X", do require stress-relieving to avoid cracking during aging.

Pressure vessels may be fabricated from the age hardenable alloys if they are welded in the annealed condition and then heated rapidly to 1625 to 1950° F. for Inconel "X" and 1400 to 1450° F. for "K" monel. They should then be cooled rapidly and aged for 8 to 20 hr.

This procedure is recommended because these alloys have low ductility at temperatures close to the aging temperature. This low ductility plus the fact that no appreciable stress relief occurs until a temperature higher than the aging temperature is reached necessitates a fast stress-relieving treatment. After welding, this treatment relieves the welding stresses before any appreciable age hardening can occur. With slow heating the combination of high residual stresses from welding and low ductility at the aging temperature frequently causes cracking. For much the same reason, welding of fully aged material is not recommended since some part of the heat-affected zone is in the low-ductility temperature range.

Although these age hardenable alloys have been successfully fabricated into pressure vessels as large



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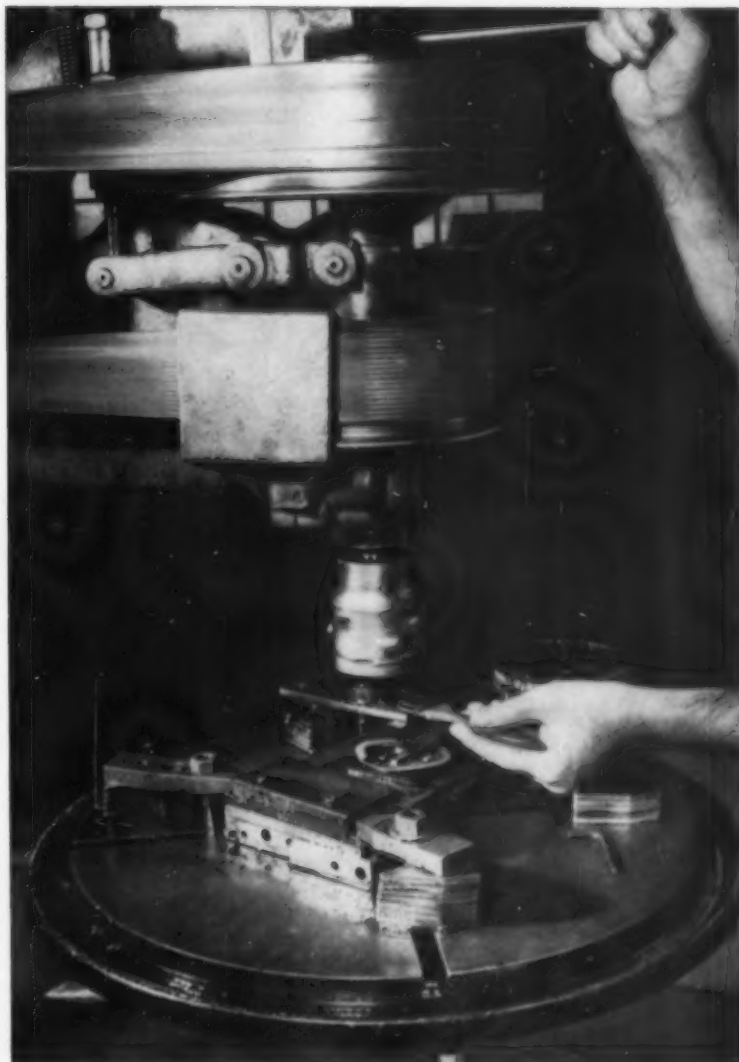


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as 7 ft. in diameter by 14 ft. long, larger structures do not appear to be feasible. Some progress is being made in developing alloys which can be fabricated in heavy sections without final heat treatment.

E. B. EVANS

## Nuclear Metals Engineering

Digest of "Metallurgy of Nuclear Power Production", by A. B. McIntosh, *The Engineer*, Vol. 200, Nov. 25, 1955, p. 759.

**T**RANSITION from orthodox methods of electric power production to nuclear systems is going to impose demands on metals which have never been required before. Even with common metals such as mild steel, aluminum, stainless steel and magnesium, broad-scale investigations of their performance under the unique conditions of the atomic furnace will be necessary before service can be guaranteed.

Present reactors proposed (in Great Britain) for the first phase of the nuclear power program are cooled by carbon dioxide gas. However, experimental reactors are being built in the north of Scotland which incorporate liquid metal cooling. In connection with the fuel elements of both types, metallurgical developments have led to the selection of a number of rare metals and to their extraction and production in the ductile state for the first time.

Constructional details of a proposed reactor depend ultimately upon its purpose, that is, whether it is intended to produce power, or plutonium, or both. Size and operating conditions of a reactor vary over an extreme range. It may be as small as a football or as large as a manufacturing plant; it may work at the temperature of liquid air or at white heat; power level may be in milliwatts or in megawatts, and the pressure may be subatmospheric or hundreds of atmospheres.

The type of reactor is determined by the neutron energies involved and this, in turn, by the "fissile" material available. Fissile material may be either uranium-235, plutonium or uranium-233. The latter is produced by neutron absorption and beta decay from thorium-232 which is found in minute quantities in ores



*Welded pressurized housing for airborne electronic equipment*

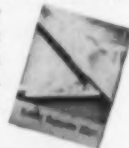
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## Nuclear Metals . . .

containing rare earth metals. To maintain a chain reaction, the reactor must contain at least the "critical" amount of one of these three, and according to the neutron energies employed and the type of fissile isotope a number of different systems of breeder or power producer may be devised.

Physical conditions of operation—temperatures, pressures, dimensions, masses and the like—are closely linked to the method of heat extraction. A homogeneous reactor, in which the core consists of a single mass of fuel material acting also as a heat transfer agent, is exemplified by liquid metal fuel reactors in which the fuel is pumped around a circuit, generating heat in the core and dissipating it directly to a heat exchanger. In a heterogeneous reactor the fuel is disposed on a lattice and is cooled by a circulating fluid which may be liquid or gaseous.

Progress in reducing costs of nuclear power depends upon the development of materials for use both as fuel and as structural components capable of withstanding increasingly severe conditions of stress, temperature, corrosion and neutron flux.

Uranium can be forged, rolled, swaged or drawn into any number of shapes including plates, rods, tubes, wires and thin foil. It has high chemical reactivity but has been hot rolled successfully in air. Cooling fluids are required to prevent spontaneous ignition of metal turnings. Welding in a completely inert atmosphere is not practical. Powder metallurgy techniques, involving hot pressing and sintering, have been applied successfully.

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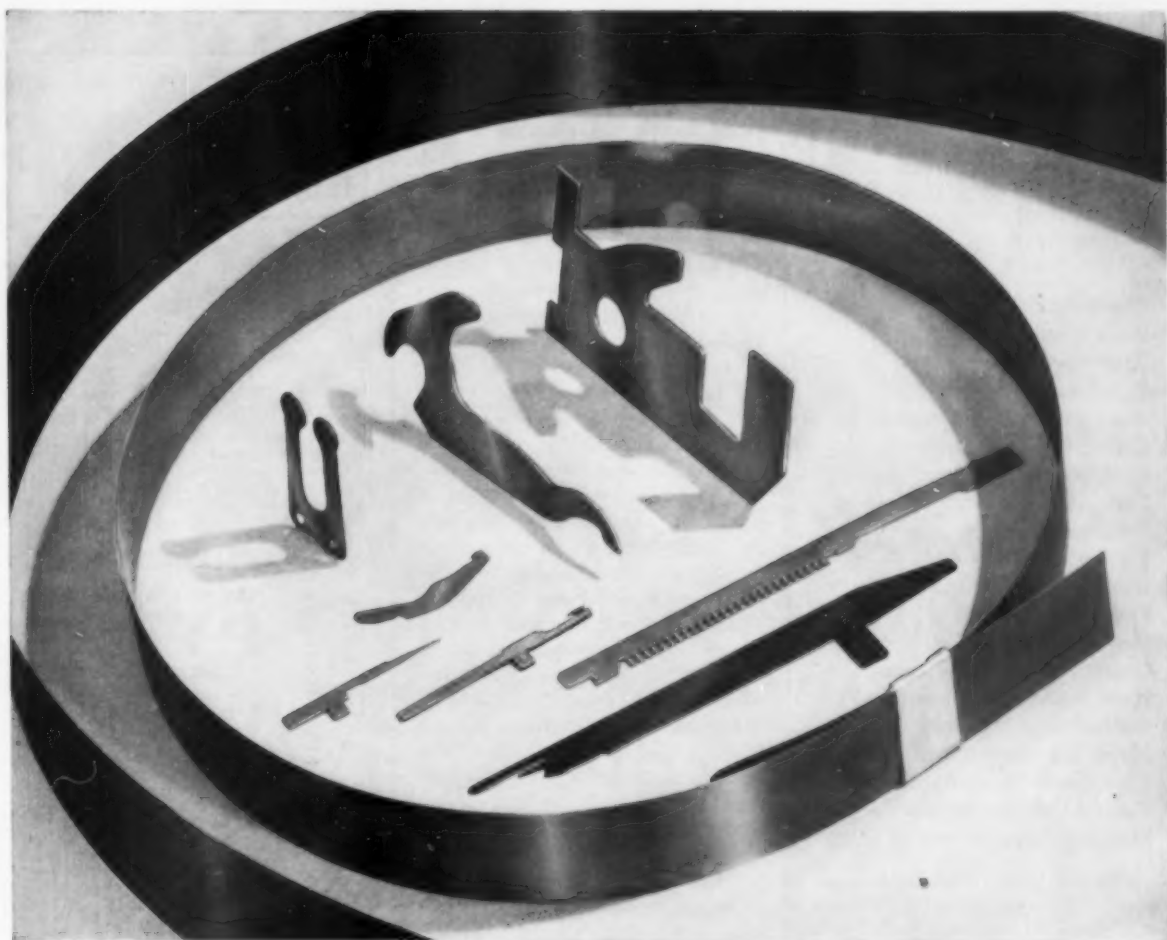
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## Nuclear Metals . . .

developing in reactor fuel of pure fissile material, alloying has been suggested. At least four different types of solid alloys have been proposed. For example, one calls for the dissemination of the fissile element in a matrix of some inert carrier absorbing few neutrons, such as aluminum, beryllium, magnesium or zirconium.

Since uranium and thorium are neither corrosion resistant nor very strong, they must be encased, or "canned", in another metal for support and protection. The two most important properties of canning materials are neutron absorption cross section and compatibility. By the latter term is meant that the canning material must not react with the fuel, the coolant or the moderator over a range of temperature beyond that rated for the reactor.

Liquid metal cooled reactors are feasible; the coolant is selected on the basis of nuclear, thermal and fluid properties. Gallium, lithium, sodium or potassium offer possibilities. On the ground of compatibility, the balance is in favor of sodium, potassium or some alloy of the two which is liquid at room temperature.

In the foregoing, principal attention has been focused on the fuel elements of the reactor. However, since components of the atomic furnace are going to be subjected to irradiation, there develops need for extensive research to show how normal physical properties of materials are affected by neutron bombardment. Many difficulties stand in the way because even in the absence of irradiation, undersanding is not complete on many of the processes involved, for example, the mechanism of deformation in creep and brittle fracture. The effect of irradiation on the stability of compounds is also important, particularly where compatibility depends upon the formation of a protective film. Simple alloys may become complex by the formation of "daughter" elements, either in solid solution or as separate phases, resulting in changed mechanical properties.

The metallurgist associated with the design and construction of nuclear power plants truly has his work cut out for him!

ARTHUR H. ALLEN

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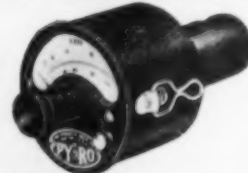
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The ideal instrument for all plant and laboratory surface and sub-surface temperature measurements. Available with large selection of thermocouples and extension arms for all jobs. Designed for ruggedness and accuracy... it features automatic cold end compensation, large 4 1/2" direct reading dial and shock, moisture and dust-proof shielded steel housing. 5 stock ranges 0-300° F. to 0-1200° F. Ask for catalog No. 148.



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Tells spot temperatures instantly in heat-treating furnaces, kilns, forgings and fire boxes. No thermocouples, lead wires or accessories needed! Temperature indicated on direct-reading dial at a press of the button. Any operator can use it. Two double-ranges from 1000° F. to 3400° F. Ask for Catalog No. 100.

### PYRO Immersion Pyrometer

The Pyro Immersion Pyrometer is shock proof, moisture proof, dust proof, immune to magnetic influences. Shielded steel housing. Instantly interchangeable thermocouples without adjustment or recalibration. Large 4" scale. Equipped with exclusive Lock Swivel. Ranges 0-1500 to 0-2500° F. Ask for Catalog No. 155.



The Pyrometer Instrument Company

BERGENFIELD 8, NEW JERSEY

Manufacturers of PYRO OPTICAL, MICRO-OPTICAL, SURFACE, RADIATION, IMMERSION and INDICATING PYROMETERS for over 25 years. Catalogs on request.

# 3 POINTS TO REMEMBER

**sodium hydride descaling is:**

**FAST**-----



**PRODUCTIVE**-----



**POSITIVE**-----



And economy makes four... four major reasons you'll want to investigate the advantages of sodium hydride descaling.

This versatile method descales a wide range of metals and alloys in only minutes. And with compact, low-cost, easily maintained equipment. No problem of waste disposal or of metal pitting. Unlike pickling, sodium hydride descaling never attacks base metal... acts uniformly on crevices and high spots alike.

If you already have a hydride descaling unit, Ethyl offers you a dependable, continuing supply of high quality sodium to operate it. If you'd like to install one, we can help there, too. With suggestions, recommendations, estimates that will put this advanced, highly efficient method to work for you promptly.

For lower labor costs, higher production, more positive descaling, mail this coupon today.

For Titanium, Carbon and Alloy Steels, Stainless Steels, High Speed Tool Steels, Cast Iron, Nickel, Inconel, Copper, Silver, Stellite.

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*Chemicals for industry*

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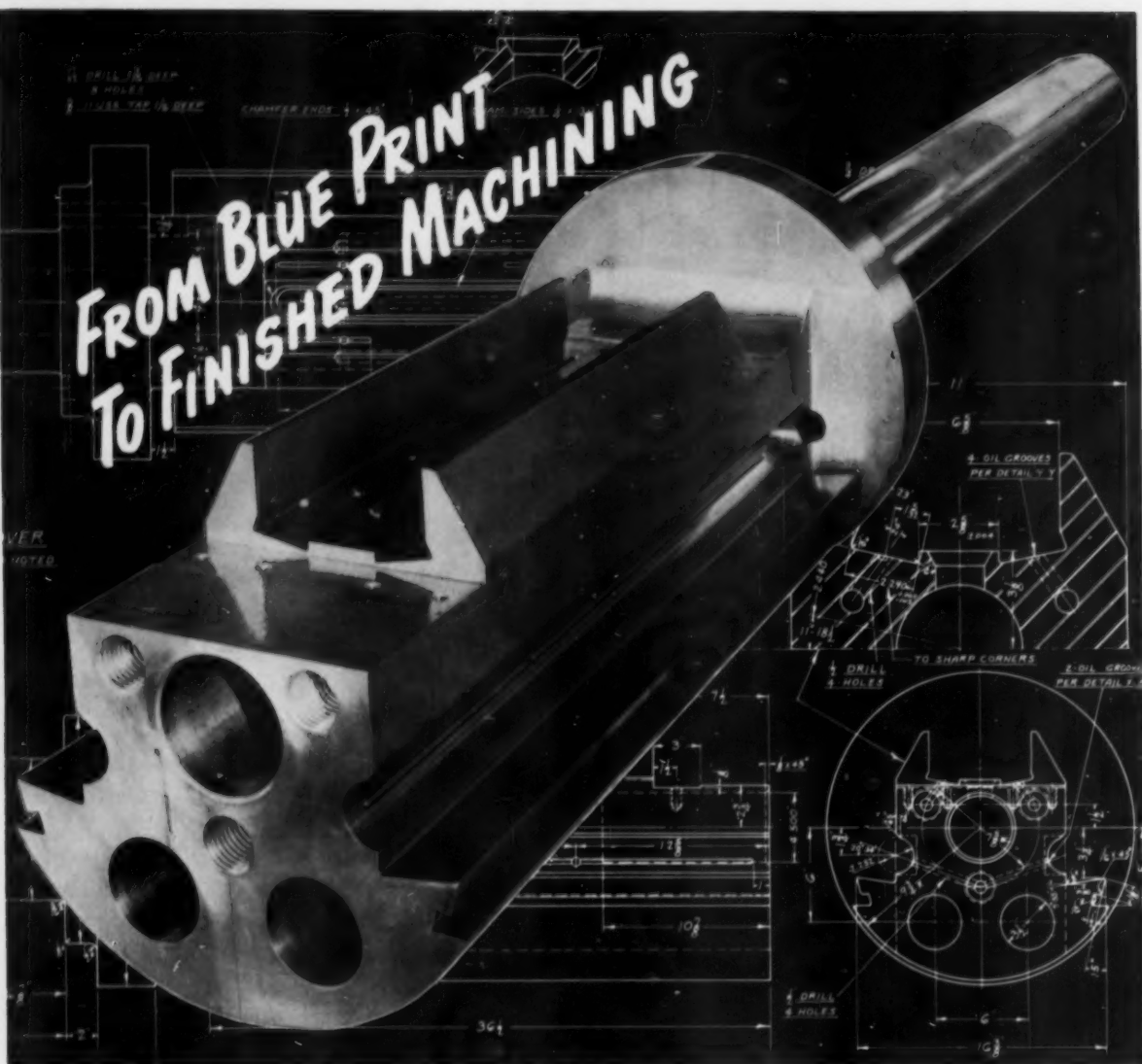


ETHYL CORPORATION  
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Please send me brochure on Sodium Hydride Descaling describing its uses, advantages, typical reactions and necessary equipment.

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WP-6-55



This Block Body for a Tension Reel represents the coordinated effort of many National Forge skills in turning out the required electric alloy steel, the proper heat treating and the intricate machining to exacting tolerances.

National Forge offers you complete forging

service in one plant—under one responsibility.

Why not take advantage of this "all-in-one" service the next time you need forgings?

For full information, write **NATIONAL FORGE AND ORDNANCE COMPANY**, Irvine, Warren County, Pennsylvania.



*At*  
**MURDOCK TOOL CO.**  
DETROIT

**MURDOCK TOOL COMPANY, INC.**  
1747 ABBOTT STREET  
DETROIT, 10  
TELEPHONE  
WOODWARD 1-5750  
December 12, 1955

Latrobe Steel Company  
Latrobe, Pa.

Gentlemen:

We wish to congratulate you on the great advancement you have made in the manufacture of High Speed Steels. Your XL steels have proved far superior to any we have ever used in machinability and finish. This is the first great improvement in steel in some time, that has really been noticeable to those of us who are machining it every day.

Your steel came to my attention so forcibly due to the fact that our employees work on a bonus arrangement based on production. When checking an increase in cost on a particular job I was informed that it was due to using regular M-2 H.S.S., rather than your XL grade. My employees constantly request your steel on their jobs. This was hard to believe at first, so therefore, we ran a test job. You will be interested in the results which were as follows:

In completely turning 400 Spotfacing Tools, made of 15/16" diameter hot rolled regular M-2 H.S.S., we used 1120 R.P.M. with a feed of .0084. To turn the complete job we broke 14 throw away carbide inserts. In comparison we turned 600 of these same tools from your M-2 XL High Speed Steel, using 1400 R.P.M. and a feed of .011. We did not break any tool bits, but wore out five of them.

In milling on these same jobs we used 110 R.P.M. with a 4 1/2" feed on the 400 pieces. It was necessary to resharpen milling cutters once on this job. On the 600 pieces we used the same R.P.M., but increased the feed to 5 1/2" per minute. It was not necessary to resharpen the cutters.

As you can see, we were not only able to increase feeds and speed by the use of your XL Steel in both milling and turning, but we also eliminated costly down time and scrap work caused by breakage of tool bits.

We heartily commend your firm for the fine job done.

Yours very truly,  
Murdoch Tool Co., Inc.  
*Robert M. Murdoch*  
Robert M. Murdoch  
President

RMS/bp

spot-facing tools made of

"Desegatized"®

**DOUBLE SIX**

**M-2 XL®**

**HIGH SPEED**

**STEEL**

*Save*

*MACHINE TIME*  
*and*  
*TOOL COSTS*



Desegatized Double Six M-2 XL is a tungsten-molybdenum high speed steel containing uniformly dispersed alloy sulphides for excellent machinability and longer tool life. The even distribution of the alloy sulphides and carbide particles is a result of Latrobe's exclusive DESEGATIZED® process of manufacture.

Considerable stocks and pieces of Desegatized Double Six M-2 XL are available from conveniently located warehouses. Order Now - Call your Latrobe representative today for complete information.

**LATROBE STEEL COMPANY**

MAIN OFFICE and PLANT: LATROBE, PA.

BRANCH OFFICES and WAREHOUSES in Principal Cities



**50 times more Gun Barrels  
with Talide® blades ...**



**Leading Arms Producer** reports outstanding service life with Talide centerless blades over past 10 years—outperforming and outlasting all other work support blades.

**Part**..... 12 gauge shotgun barrel.

**Operation**..... Grind entire gun barrel simultaneously to series of compound angles.

**Machine**..... No. 5 Cincinnati Centerless Grinder.

**Blade**..... Special Talide-tipped work support blade 34½" long, having 9 steps and 10 compound angles ground to .0001" tolerance.

**Results**..... Talide-tipped blades last 150 days per grind—hardened steel blades 3 days. Several Talide blades have been in continuous production for over 5 years—being retipped with a new Talide metal wear strip every 12 to 18 months.

**Tolerance**..... Talide blades, due to their negligible wear over long periods of service, enabled the above Arms Producer to maintain the extremely close tolerances required on the above part—and at less cost than possible with any other tooling.



One-piece Talide strip (up to 100" without seams) prevents scoring and scratching. Write for new 84-page Catalog 56-G or ask for sales engineer to call. . . . Metal Carbides Corporation, Youngstown 12, Ohio.

#### **1,000,000 CUTS WITH TALIDE SHEAR BLADES!**

A large mid-west electrical equipment manufacturer reports exceptional service life with Talide-tipped shear blades 39" long cutting silicon steel for transformers. Over 1,000,000 cuts are being obtained per blade, compared to 8,000 cuts with a hi-carbon, hi-chrome blade. Burr-free, clean-cut edges produced with scrap rate practically eliminated.



#### **STANDARD OR SPECIAL CENTERLESS BLADES!**



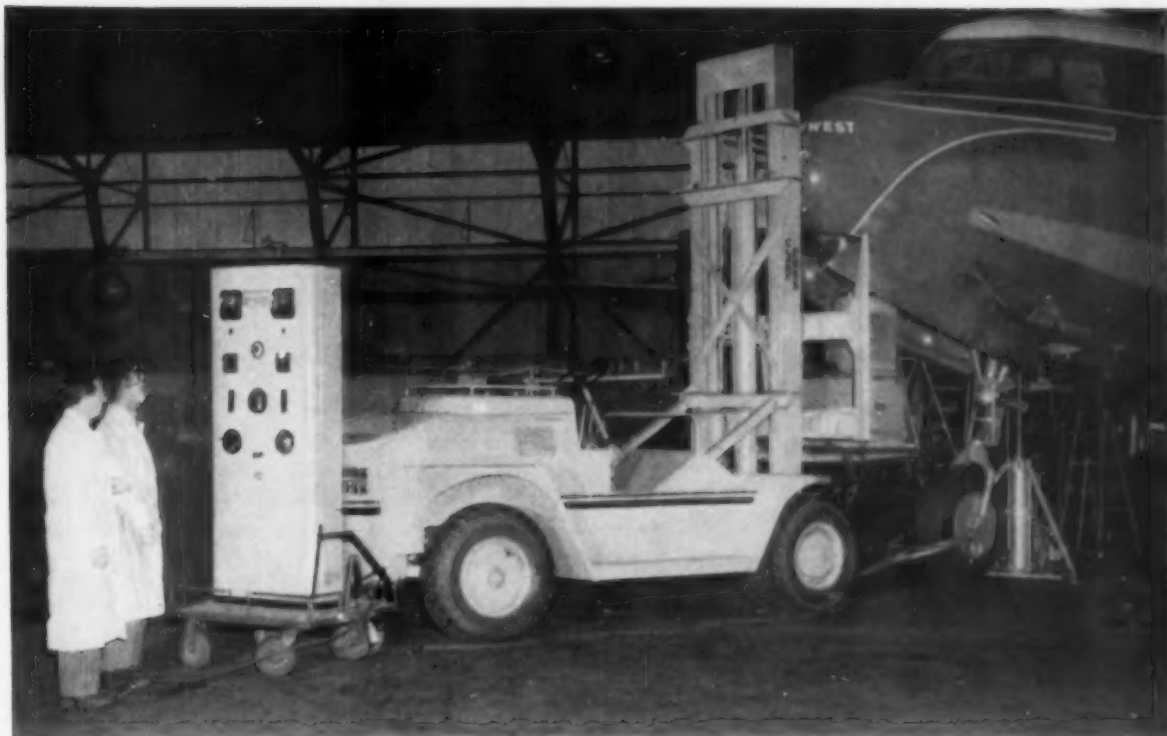
Standard Talide-tipped blades are available from stock in over 50 styles and sizes for both Cincinnati and Landis Centerless Grinders and for either infeed or thru-feed work. Special blades to handle parts having steps, tapers or profiles can be made promptly to special order. Blades can be supplied in lengths up to 100" and ground to any tolerance or shape.

#### **4,600 MILES OF SCOTCH TAPE CUT!**

A leading producer of scotch tape installed a set of Talide rotary slitter knives 5 years ago on a line cutting scotch tape to size. The original set of knives have, to date, cut 7,000,000 yards of scotch tape with no signs of wear—no re-sharpening—and no downtime experienced. Officials have decided to equip over 100 shearing machines with Talide knives as a result of the above phenomenal performance.



HOT PRESSED AND SINTERED CARBIDES • VACUUM METALS  
HEAVY METAL • CERMETS • HIGH TEMPERATURE ALLOYS  
OVER 25 YEARS' EXPERIENCE IN TUNGSTEN CARBIDE METALLURGY



Nose wheel landing strut piston is inspected with a G-E OX-250. Power of 250,000 volts permits short exposure times without disassembly.

## YOU FLY MORE SAFELY when G-E x-ray units speed aircraft inspection

**X**-RAY inspection-without-disassembly is routine preventive maintenance at the St. Paul, Minn., overhaul depot of Northwest Orient Airlines. Records show their two General Electric x-ray units not only save time and money, but also contribute to longer parts service life. Oil cooler radiator overhaul, inspection of nose wheel strut piston . . . examination of prop blades . . . welds — these are typical jobs now assigned to x-ray.

And the widespread use of General Electric x-ray apparatus is not limited to airlines. Thanks to specialized G-E engineering, all industry is able to speed inspections of complete metal structures. Compact x-ray tubeheads can be passed through small opening for radiographic examinations of welds and castings. Aircraft structures, ship hulls, pressure vessels, steam pipes are just a few of the products that are tested nondestructively, at low cost.

Have you considered x-ray for inspection and quality control? Ask your G-E x-ray representative for facts on this complete line of x-ray equipment. Choice of 25 models in every practical voltage range. Or write X-Ray Department, General Electric Company, Milwaukee 1, Wisconsin, Room AS-64.



Industry's most versatile x-ray unit, the OX-175, is used to check oil cooler radiator. Cost of x-ray examination: \$5.00. Previous mechanical inspection cost \$40.00—and required removal of coring, thus shortening life of radiators.

*Any G-E x-ray apparatus can be yours—without initial capital investment—on the Maxiservice® rental plan.*

*Progress Is Our Most Important Product*

**GENERAL  ELECTRIC**



## AMPCO<sup>®</sup> METAL quadruples life of polished rod liners

*Critical part sets new records in tough  
oil-well service, thanks to Ampco  
Metal's remarkable corrosion- and  
sliding-wear resistance*

In oil well pumping the 14 to 16-foot polished rod liner really takes a beating. As you can imagine, sliding wear, in this extra-long bushing, is a real problem when you consider the number of strokes made by a pump during an operating day. Corrosion enters the picture, too, with the liner often in contact with salt water, sulfides, etc.

With ordinary bronzes, Cities Service Oil Company found frequent replacement to be a constant headache. Then, in certain areas, it switched to liners made from Ampco Metal Pipe. Cities Service engineers report a substantial reduction in liner replacements.

Ampco Metal Liners last four times as long as plain bronze liners because they are made from a unique aluminum bronze alloy. It's a remarkable bearing material—has unusual resistance to mechanical wear. It withstands the corrosive effects of many acids and caustics. And when used as pipe it combats erosion from solids held in suspension.

Ampco pipe and tubing is available in all sizes, along with a complete line of flanges and fittings. Send coupon today for full information.

\*Reg. U. S. Pat. Off.

### AMPCO METAL, INC.

Dept. Milwaukee 46, Wisconsin

I'm interested in knowing more about the wear- and corrosion-resistant properties of Ampco Metal. Please send me complete information.

Name.....Title.....

Company.....

Company Address.....

City.....( ) State.....



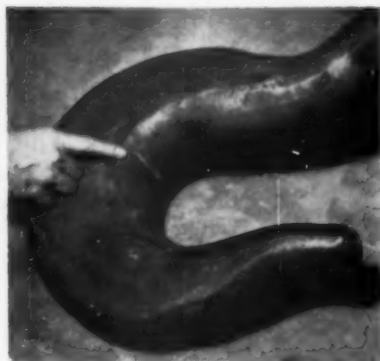
**AMPCO METAL, INC.**

*Sole Producer of Genuine Ampco Metal*

Main Office and Plant  
Milwaukee 46, Wisconsin  
West Coast Plant  
Burbank, California



**THE ELECTRIC DETECTIVE** is an apt description of the Magnatest FM-100 Conductivity Meter. Magnatest uses the electrical conductivities of materials as a measure of uniformity, hardness, purity and other characteristics. A small hand held coil induces eddy currents in the test material, which in turn affect the impedance of the coil in proportion to the conductivity of the material.



**IT'S JUST A LITTLE CRACK**, but it's a serious matter when it shows up on an industrial crane hook. In fact, to the naked eye it may appear to be a scratch, at most. Yet it can open further and further under load. The end result: failure in service and subsequent costly damage. Photo above shows a Magnaflux indication of such a crack in a crane hook.

THE HALLMARK  
OF THE BEST  
SYSTEMS FOR  
NONDESTRUCTIVE  
TESTING



Write for complete details concerning any of the above case studies, or ask for our new booklet on "Lower Manufacturing Costs."

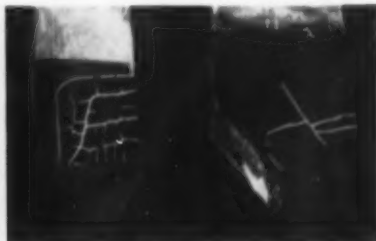
## Case Studies: NONDESTRUCTIVE TESTING SYSTEMS



## How Periodic Inspection Ups Production by Preventing Equipment Failures

When industrial equipment fails in use, it usually results in lost time, production, or even life! In each case there is a corresponding loss of money. The amount, of course, depends upon the circumstances. Periodic inspection with an M testing system can foretell the exact nature and extent of structural weaknesses in your machinery, tanks, or equipment.

Invisible hairline cracks are warning signs of future fatigue failure. The M tests detect such signs in any material. You can take the proper corrective steps in time to prevent costly production interruptions. Nondestructive testing can help you eliminate profit-draining equipment failures. —Investigate Magnaflux inspection methods today!



### ZYGLO "SPOTLIGHTS" SERIOUS DEFECTS IN CUTTING TOOLS

Zyglo inspection employs an oil base penetrant that is brilliantly fluorescent under "black light". It detects surface cracks or pores when they may

affect the service life of any metal part. Whether you produce cutting tools, or use them, Zyglo provides better inspection at lower cost.

Take Your Inspection Problems to the House of Answers

**MAGNAFLUX CORPORATION**

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Wissco Belts travel stamped aluminum plates for domestic refrigerator evaporators through multi-temperature-zone brazing furnace. This is another example of how...

## FAMOUS NAMES

*ride on* **WISSCO BELTS**

*Reynolds Metals Company • Louisville, Ky.*

Reynolds Metals Company, recognized as a leader in the aluminum industry, uses 80-20 alloy Wissco Rod Reinforced High Temperature Belts in this production-line operation at its Louisville plant.

The Wissco Belts are repeatedly subjected to elevated temperatures ranging from 1025° F. to 1190° F. and to the corrosive action of a salt flux. Wissco Belts have been used since the Reynolds plant was opened. They are standing up extremely well, and give economical service with minimum maintenance.

Wissco Alloy Processing Belts are the choice of many famous names in industry—leaders in their fields. You, too, will find Wissco the

most economical and efficient belt for high temperature jobs—for metals, ceramics, glass annealing and decorating.

**For details, just write or call our nearest office:**

THE COLORADO FUEL AND IRON CORPORATION  
Denver and Oakland

WICKWIRE SPENCER STEEL DIVISION  
Atlanta • Boston • Buffalo • Chicago • Detroit • New Orleans  
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**WISSCO BELTS**  
PRODUCT OF WICKWIRE SPENCER STEEL DIVISION  
THE COLORADO FUEL AND IRON CORPORATION

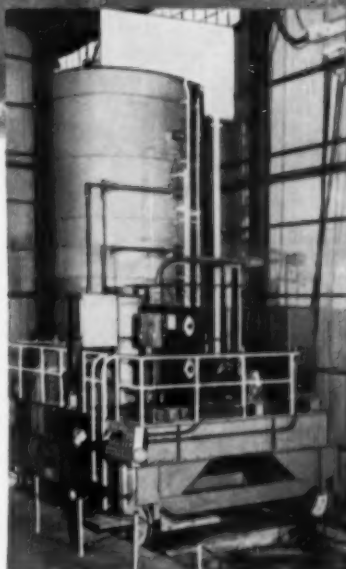


Metallurgical, Inc. chooses

## Armour Ammonia

when heat treating jet plane parts!

Bright, scale-free  
steel parts are  
hardened to  
critical tolerances  
under dissociated  
ammonia atmosphere  
provided from  
Armour Ammonia!



With the world's largest commercial vertical drop bottom metal treating furnace, METALLURGICAL, INC. of Minneapolis, Minnesota, heat treats parts of extreme length and diameter.

### CLIP AND MAIL TODAY!

Air Force specifications call for extremely close tolerances and the ultimate in structural strength and durability. Metallurgical, Inc. has found that the dryness and extreme purity (99.98%) of Armour Ammonia is a prime factor in obtaining such results.

More and more companies are using Armour Ammonia for modern metal treating techniques, such as nitriding, carbonitriding and the use of dissociated ammonia in the bright annealing of stainless steel and for furnace brazing. They find the use of dissociated ammonia can cut operating expenditures up to 55% because a single cylinder of Armour Ammonia dissociated yields the equivalent of 34 cylinders of hydrogen!

The Armour Technical Service Department will help answer problems arising with ammonia installations for metal treating. Send today for these free booklets. If your problems are unusual or pressing, write giving full details.

Armour Ammonia is available in 116 cities.  
Save money on our tank truck delivery service!

Please send me free booklets which I have checked:

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- ☐ "The Role of Water Vapor and Ammonia in Case Hardening Atmospheres"
- ☐ "Case Hardening of Steel by Nitriding"
- ☐ "A Survey of Industrial Carbonitriding Practice"
- ☐ "Investigation into the Carbonitriding of Plain Carbon Steel"
- ☐ "The Carbonitriding of Alloy Steels"
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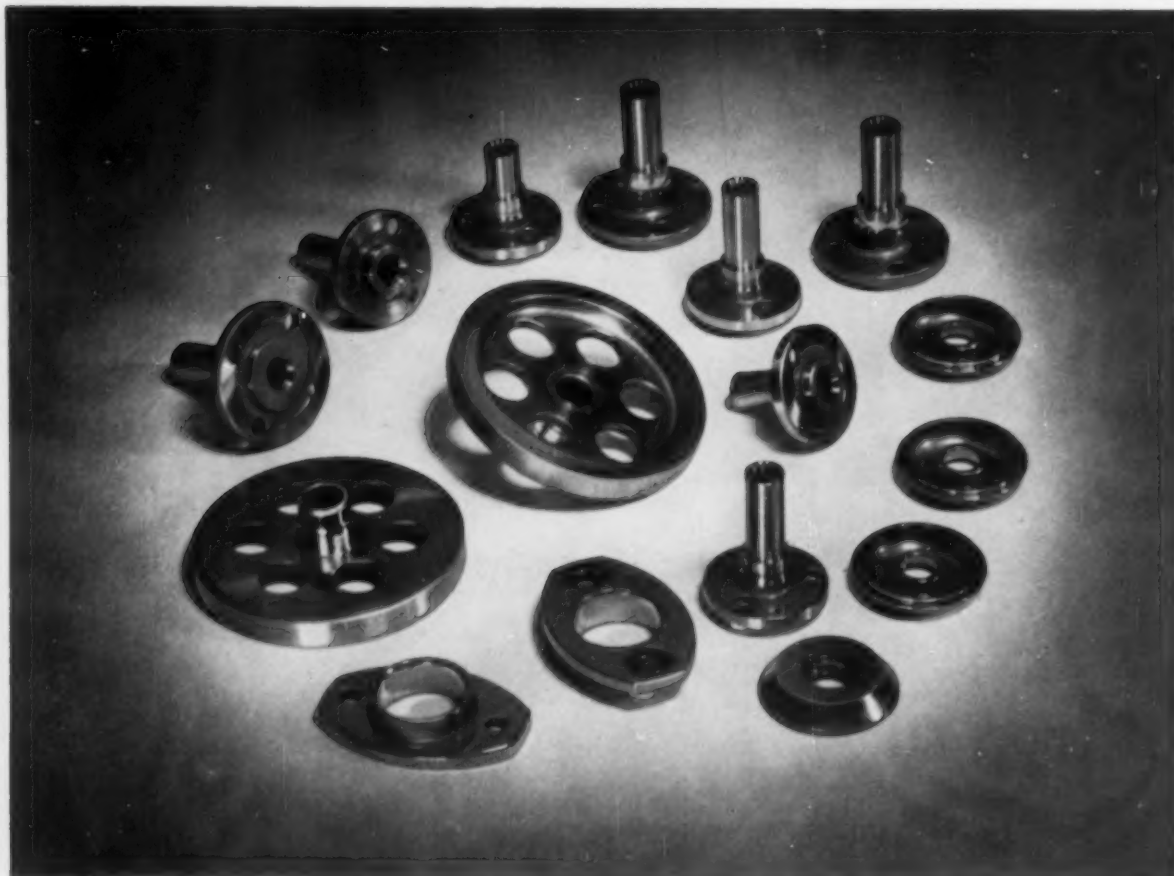
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*Ammonia Division*

Armour and Company • 1355 West 31st Street • Chicago 9, Ill.



## bearing manufacturer gains over 300% higher yield with Vacuum Metals FERROVAC

Because a leading manufacturer of precision instrument bearings worked to such exacting standards, he experienced an exceptionally high rate of rejection of finished parts. Then they tried Vacuum Metals FERROVAC®... of the same basic analysis as the air-melted grade used previously. The results were decisive. Rejections were reduced to less than 1% — a yield improvement of better than three times.

That's to be expected from vacuum-melted alloys, because of their remarkable uniformity. Gases that cause inclusions and that in turn lead to rejection — or early bearing failure — are literally sucked from vacuum-melted alloys during production... before the metal becomes solid.

The result is a *clean* alloy — with many of its properties improved. It is stronger, tougher, far more

resistant to wear and fatigue. It works longer and harder than conventionally-melted alloy — even does the super-tough jobs where *nothing else* will work.

*Only Vacuum Metals gives you one-source service* — Vacuum Metals' own large organization, and its affiliation with National Research Corporation and Crucible Steel Company of America, brings you a fully integrated service. It includes everything from melting and casting, through mill rolling and nationwide distribution of finished products. If you have an application where you can use vacuum-melted metals — in experimental lots or production quantities — Vacuum Metals can serve you. Write us now, outlining your requirements. *Vacuum Metals Corporation, P. O. Box 977, Syracuse 1, New York.*



# VACUUM METALS CORPORATION

Jointly owned by Crucible Steel Company of America and National Research Corporation



## News about COATINGS for METALS

Metallic . . . . . Organic . . . . . Decorative . . . . . Protective

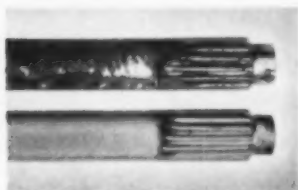
# New plastisol sprays extra-thick coating

### Crack-Free Chromium Plate solves rusting problem

The recently developed Unichrome process which deposits a chromium plate free from cracks is proving superior to ordinary chromium in certain types of applications . . . notably, where durability and protection are the prime requirements.

#### PROVES IDEAL IN WASHING MACHINE

Steel drive shafts in well known washing machines are now plated directly with Crack-Free Chromium about .0005" thick. Unlike ordinary chromium, this deposit has no microscopic cracks to admit water, humidity, soap and detergent spillage. Shafts stay rust-free, and get extra wear-resistance, besides.



With .0005" of ordinary chromium, shaft at top rusted badly after 100 hours salt spray; same thickness of Crack-Free Chromium protected shaft at bottom in same test.

Many other important protective features of Unichrome Crack-Free Chromium are detailed in Bulletin CFC-1. Send for copy.



#### METAL & THERMIT CORPORATION

General Offices: Rahway, New Jersey  
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Metal & Thermit—United Chromium  
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### Unichrome "Super 5300" Coating builds 60 mil film per coat . . . gives heavy duty corrosion-protection



Tank getting a heavy protective coating with Unichrome Plastisol. Large structural parts of products can likewise be durably finished.

A new and unusual plastisol formulation has been developed by Metal & Thermit, a pioneer in this type of coating. Unichrome "Super 5300" Coating delivers the full solids content of vinyl plastisol right through a spray gun. It enables a coat 60 mils or more to be applied successfully in one application.

#### THICK AND TOUGH

Amounting to a vinyl "sheet" material, single or multiple coats of this new plastisol can be used to good advantage on many of the products where plastic or rubber sheets are generally specified. Super 5300 Coating also provides a durable, protective finish for large uneven surfaces where only a fluid material can be applied. Good performance is assured for two reasons. (1) With spraying, there are no seams or joints where corrosives might penetrate. (2) Vinyl plastisols have a

unique combination of chemical and physical properties.

#### THE ADVANTAGES

Curing quickly at 350° to 365°, Unichrome Plastisols form rugged, resilient coatings with an attractive satin finish. They insulate electrically, absorb impact, don't chip or crack, resist abrasion and erosion, deaden sound.

They give extraordinary protection against a wide range of acids, alkalis, alcohols, salt solutions and moisture. With plastisol protection, ordinary metal parts and products often prove suitable for unusually severe service conditions.

For companies without adequate baking facilities, Metal & Thermit can recommend nearby firms that specialize in applying "Super 5300" Coating. Send for Bulletins that tell more about plastisols.



## Large OD Thin Wall Tubing offers New Answers to Design Problems

***Superior specializes in an unusually wide range of analyses, shapes and sizes***

Today's design engineers are finding large OD thin wall tubing by Superior answers more and more of their design problems. Its light weight makes it ideal for ducting, fuel and oil lines in aircraft. Thin wall tubing also functions efficiently as a low pressure heat exchanger tube. Because of its close tolerances, ductility, and bright, clean OD and ID surfaces, Superior thin wall tubing is an excellent choice for flexible metal hose for the food, chemical and aircraft industries. Other applications include bellows, solenoid cylinder cores, cylinder liners for automobile hydraulic brakes, fractional horsepower motor casings, ceramic drills, electron power tube anodes and cathodes, and casings for radioactive well logging instruments.

A number of analyses in large OD thin wall seamless and

Weldrawn® tubing are available at Superior. Stainless, carbon and alloy steels, beryllium copper, titanium, nickel and nickel alloys are offered in sizes up to 1 1/4" OD with .035" wall maximum; Monel and certain analyses of stainless steel in sizes to 2 1/2" OD with .025" wall maximum.

Superior tubing can be supplied in random, multiple or cut lengths up to 30 feet, and in any of three standard tempers (fully annealed, soft; half-hard drawn; full-hard drawn) or in special tempers required by Government, aircraft and customer specifications. Thin wall tubing can be shipped in special cardboard cylinders, to protect it from dents and scratches.

For additional information, get your free copy of Data Memorandum No. 4. Write to Superior Tube Company, 2008 Germantown Ave., Norristown, Pa.

# *Superior Tube*

The big name in small tubing

**NORRISTOWN, PA.**

*All analyses .010" to 3/4" OD—certain analyses in light walls up to 2 1/2" OD*

West Coast Pacific Tube Company • 5710 Smithway St., Los Angeles 22, Calif. • Raymond 3-1331



The gears in an automatic nut former have to be tough and strong to withstand heavy, varying loads. Yet, the castings from which they're made should be easy to machine. That's

why this gear for a Waterbury Farrel Automatic Nut Former is made from ASTM-50 gray iron with a nominal composition of 1% nickel and .50% molybdenum.

## Moly gives cast iron gears higher strength with toughness and good machinability

"To insure a tough, easily machined gray iron for the gears in our Automatic Nut Formers," says Henry C. Griggs, Metallurgist for Waterbury Farrel Foundry & Machine Co., "we specify .50% molybdenum in our ASTM-50 material. The properties of this material contribute importantly to the reputation of Waterbury equipment for accuracy and high speed production under severe operating conditions."

Molybdenum helps to give reliable and reproducible castings — very important factors in consistent performance of gears.

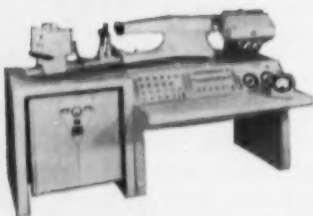
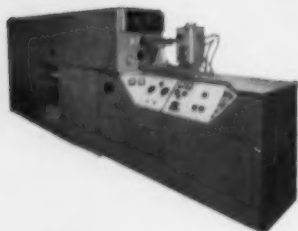
Investigate moly irons. They may be the key to better performance in many of your gear applications.

For the first two in a series of bulletins, "Why Moly Iron," or for technical assistance, write Climax Molybdenum Co., Department 5, New York 36, N. Y.

# CLIMAX MOLYBDENUM



*Research or  
production control  
analysis problem?*



## One of these Instruments will solve it!

Nearly every business has an analysis problem — either in research, production control or a combination of the two. Now, whether your budget is large or small, whether your requirements are critical or routine, JAcO has an instrument tailored to your needs.

### JAcO Ebert Convertible Spectrograph

... for analysis of a wide variety of materials in the most exacting research or production control work. This instrument is the finest produced by the world's leading manufacturer of large grating spectrographs. Unmatched for power, versatility and flexibility.

### JAcO Spec-Lab

... for production control and routine research. The low-cost Spec-Lab brings to all the advantages of spectrochemical analysis long enjoyed by the few. Includes precision spectrograph, source, microphotometer, photoprocessor, calculating board and other needed accessories in an easy to use form.

### JAcO Atomcounter Direct Reading Spectrometer

... for production control or routine analysis. The ideal high sensitivity instrument for applications requiring fast, accurate results. Employs modern electronic system similar to those found in computers and scalars.

### JAcO-Hilger Direct Reader

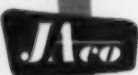
... for production control. A sturdy 11-element direct reader that is low in cost yet has speed and accuracy equal to the most expensive. Simple and easy to operate. Features a temperature compensator and analysis by read-out meter or optional recorder. Installed, calibrated and serviced by nationwide JAcO branch offices.

JAcO Covers the Spectrum



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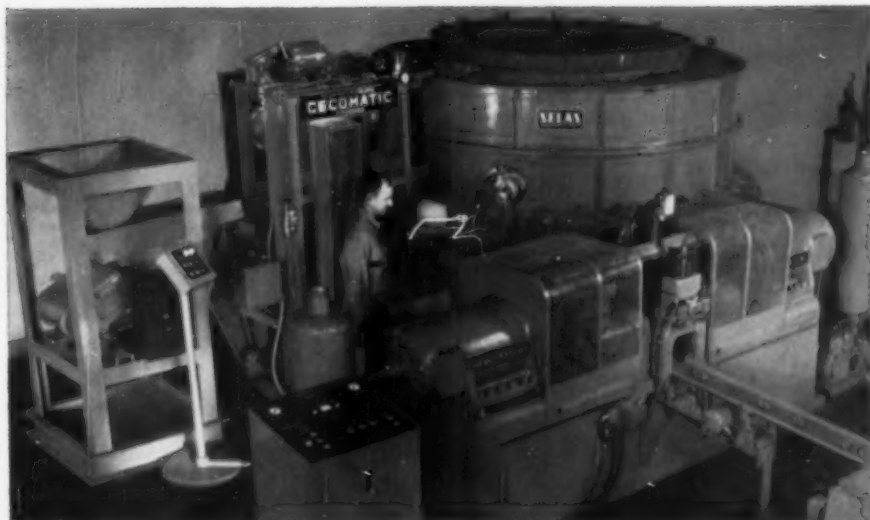
Atlanta, Ga.      Muskegon, Mich.  
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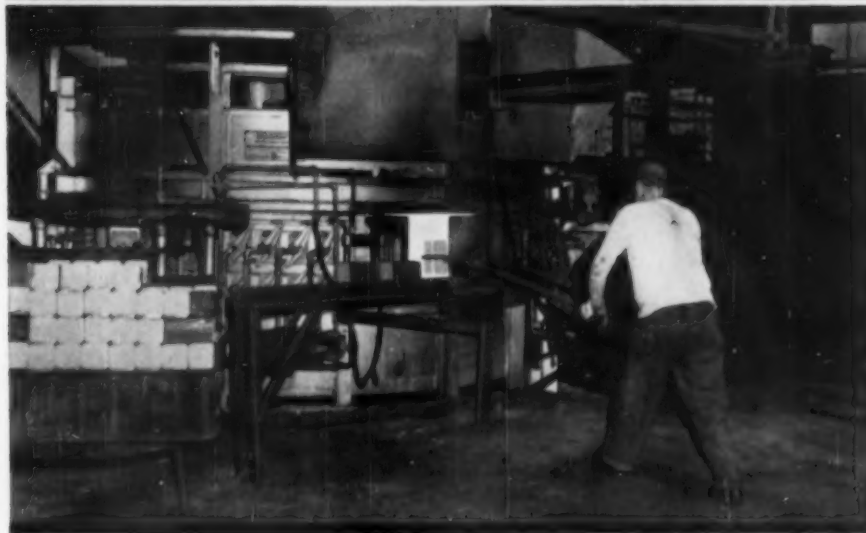
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# Special Reports

## On Finishing Non-Ferrous Metals

### NUMBER II—Paint Base, Corrosion-Resistant Finishing with Iridite

#### WHAT IS IRIDITE®

Briefly, Iridite is the tradename for a specialized line of chromate conversion finishes. They are generally applied by dip, some by brush or spray, at or near room temperature, with automatic equipment or manual finishing facilities. During application, a chemical reaction occurs that produces a thin (.00002" max.) gel-like, complex chromate film of a non-porous nature on the surface of the metal. This film is an integral part of the metal itself, thus cannot flake, chip or peel. No special equipment, exhaust systems or specially trained personnel are required.

Chromate conversion coatings are well known and accepted throughout industry as an economical means of providing corrosion protection, a good paint base and decorative finishes for non-ferrous metals. However, continued developments have been so rapid and widespread that many manufacturers may not be completely aware of the breadth of application of this type of finish. Hence, this digest of current information; to bring you up to date on the many ways in which you can obtain proper surface preparation for painting and increase product durability with a single multi-purpose chemical pretreatment. Report I on decorative, corrosion-resistant finishes and Report III on chemically polished, corrosion-resistant finishes are available on request.

First, it is an accepted fact that metal surfaces should be prepared before painting to make possible an efficient paint system. Naturally, this preparation should provide for good initial paint adhesion. Chemical treatments have proved extremely effective in this respect, particularly those of a neutral or preferably acid nature. Further, to be most efficient, chemical treatments should provide a non-porous barrier to maintain adhesion by sealing the metal from the paint and moisture. They should also provide a self-healing film which prevents lateral corrosion in the event that bare metal is exposed through scratching.

The Iridite chromate conversion coatings meet all these requirements. Iridite

is a chemical conversion treatment for surface preparation. It provides initial paint bonding by molecular adhesion. It is acid in nature and produces a film that is gel-like and non-porous in structure. Thus, the Iridite film effectively seals the metal from the paint and from moisture penetration. Because the film contains certain relatively soluble constituents, it will protect areas scratched through to bare metal and prevent lateral corrosion. This is accomplished by a gradual leaching of these constituents into the damaged area.

Further, because of its gel-like, non-crystalline nature, the Iridite film will not affect the appearance or texture of the paint film, nor will it dust or powder to mar the painted surface. Because the film is non-porous, paint coverage is increased, thus substantial savings in paint costs will be realized. In addition, treated parts may be stored for long periods of time prior to painting without the risk of entrapped moisture causing blistering when painting.

Iridite chromate conversion coatings are widely used with equal ease and success under both baked and air-dried paint systems. While the actual adherence properties of the Iridite film do not increase appreciably with its thickness, corrosion protection does. The protection of the Iridite film is proportionate to its thickness and should be taken into consideration when selecting the Iridite to meet your needs. However, it is sometimes necessary to sacrifice maximum corrosion protection for appearance when a finished

part is to be only partially painted. For example, it may be desirable to use a thin, clear, bright Iridite film if the unpainted areas must present a chrome-like appearance. A typical case is that of instrument housings on which the exterior is painted and the inside left unpainted.

On the other hand, if all surfaces of the product are to be painted and maximum corrosion protection is required, the heavier and most protective Iridite films should be used. For example, all surfaces of zinc die cast fruit juicers are finished with a highly protective Iridite film prior to painting to provide maximum resistance to the corrosive action of fruit juices.

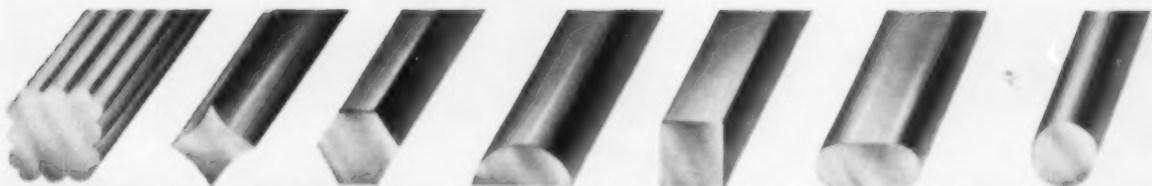
Iridite finishes are now available for all commercial forms of the more commonly used non-ferrous metals, including zinc, cadmium, aluminum, magnesium, silver, copper, brass and bronze. In addition to providing an excellent base for paint, the Iridite films also have high decorative value when used as final finishes in themselves.

These films can produce a wide variety of pleasing appearances including clear bright, iridescent yellow, bronze, olive drab and brown. In addition, many films can be modified by bleaching or by dyeing. Among the dye colors available are various shades of red, yellow, green, blue or black.

In planning or designing, you should consider the many other characteristics of Iridite finishes which may enter into the specific problem. In addition to their functions as protective and decorative finishes, and as bases for organic finishes and bonding compounds, Iridites have low electrical resistance. Some can be soldered and welded. The film does not affect the dimensional stability of close tolerance parts.

Iridites are widely approved under both Armed Services and industrial specifications because of performance, low cost and savings of materials and equipment.

You can see then, that with the many factors to be considered, selection of the Iridite best suited to your product requires the services of a specialist. That's why Allied maintains a staff of competent Field Engineers—to help you select the Iridite to make your installation most efficient in improving the quality of your product. You'll find your Allied Field Engineer listed under "Plating Supplies" in your classified telephone book. Or, write direct and tell us your problem. Complete literature and data, as well as sample part processing, is available. Allied Research Products, Inc., 4004-06 East Monument Street, Baltimore 5, Maryland.



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Precision temperature control of the three Lindberg-Fisher furnaces is maintained through these conveniently grouped panels.

From left to right, Robert W. Scott, Virgil L. Shoemaker and Del T. Kay, general partners, SKS Die Casting Company.

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Melting Furnaces. These fulfilled our requirements completely and represented an *outstanding improvement* over our previous methods."

Like SKS, you will also find that Lindberg-Fisher Induction Melting and Holding Furnaces provide these advantages: cleaner molten metal, continuous production, cooler operation and minimum maintenance. Ask us to recommend the proper type of furnace for your particular needs or write for our Bulletin 560.

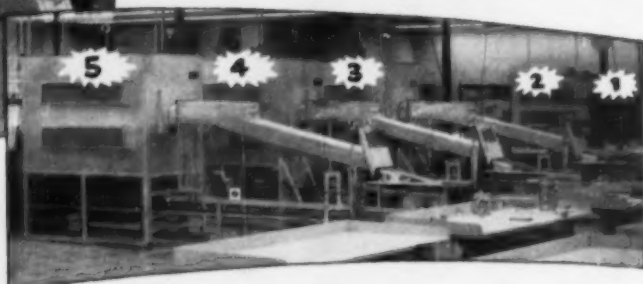
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Contents include an introduction, the importance of beryllium, occurrence of ores and their treatment, reduction to metal, processing and fabrication, properties, the brittleness problem, metallography, corrosion, beryllium-rich alloys, cermets and ceramics, health hazards and analytical chemistry of beryllium.

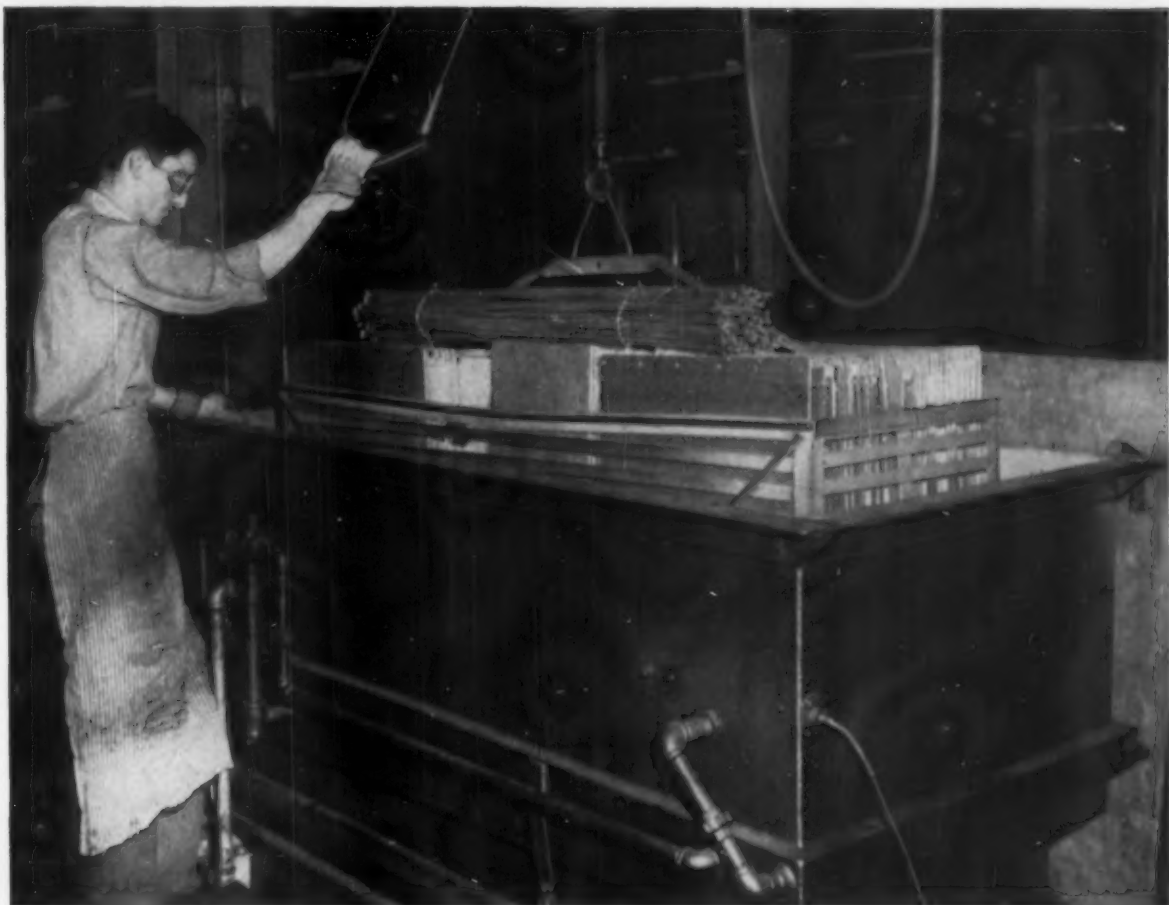
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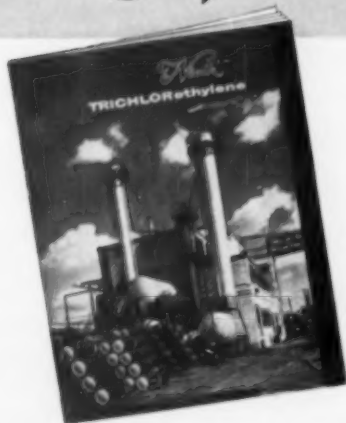
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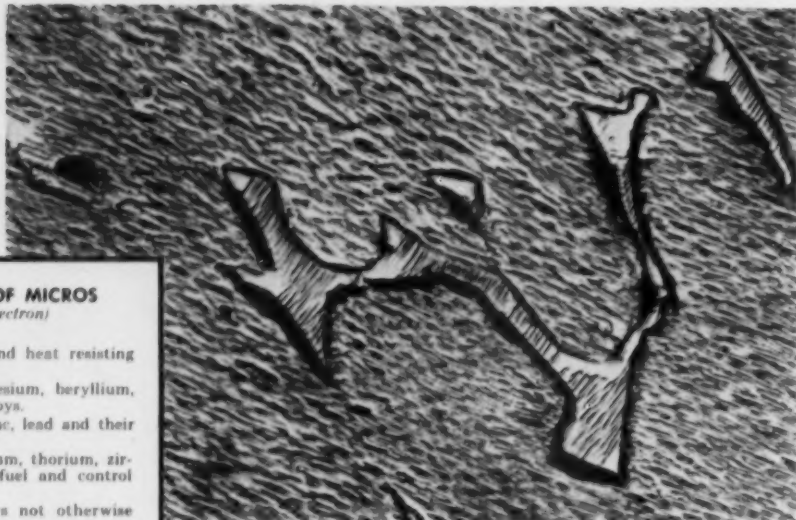
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- Class 4. Copper, nickel, zinc, lead and their alloys.
- Class 5. Uranium, plutonium, thorium, zirconium and reactor fuel and control elements.
- Class 6. Metals and alloys not otherwise classified.
- Class 7. Series showing transitions or changes during processing.
- Class 8. Welds and other joining methods.
- Class 9. Surface coatings and surface phenomena.
- Class 10. Results by unconventional techniques (other than electron micrographs).
- Class 11. Slags, inclusions, refractories, cermets and aggregates.
- Class 12. Color prints in any of the above classes (no transparencies accepted).

*Entries are invited in the 11th ASM Metallographic Exhibit, to be held at the National Metal Exposition in Cleveland, Oct. 6 through 12, 1956.*

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Work which has appeared in previous metallographic exhibits held by the American Society for Metals is unacceptable. Photographic prints should be mounted on stiff cardboard; maximum dimensions 14 by 18 in. (35 by 45 cm.) Heavy, solid frames are unacceptable. Entries should carry a label on the face of the mount giving:

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A committee of judges will be appointed by the Metal Congress management which will award a First Prize (a medal and blue ribbon) to the best in each classification. Honorable Mentions will also be awarded (with appropriate medals) to other photographs which, in the opinion of the judges, closely approach the winner in excellence. A Grand Prize, in the form of an engrossed certificate and a money award of \$100, will also be awarded the exhibitor whose work is judged best in the show, and his exhibit shall become the property of the American Society for Metals for preservation and display in the Society's national headquarters in Cleveland.

All photographs may be retained by the Society for one year and placed in a traveling exhibit to the various Chapters. They will be returned to the owners in May 1957 if so desired.

## 38<sup>TH</sup> NATIONAL METAL CONGRESS AND EXPOSITION

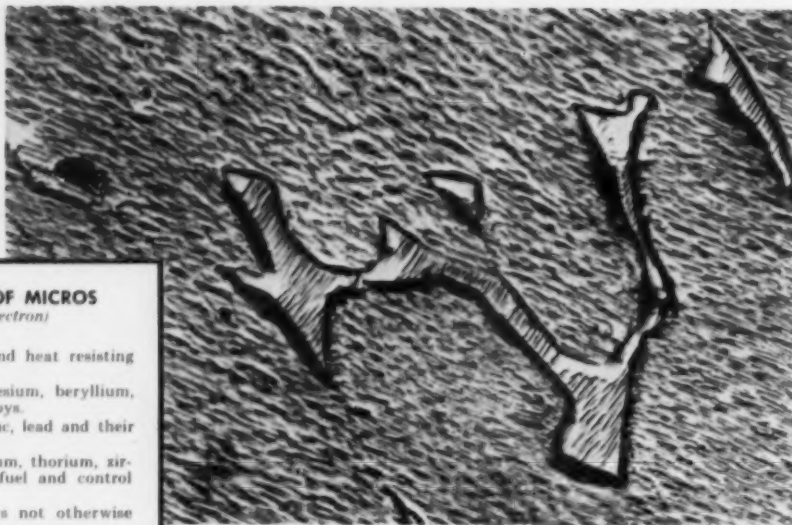
CLEVELAND, OHIO

OCTOBER 6 to 12, 1956

THE INDEX

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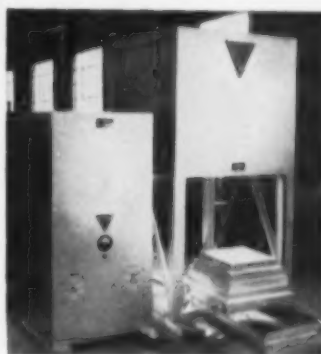
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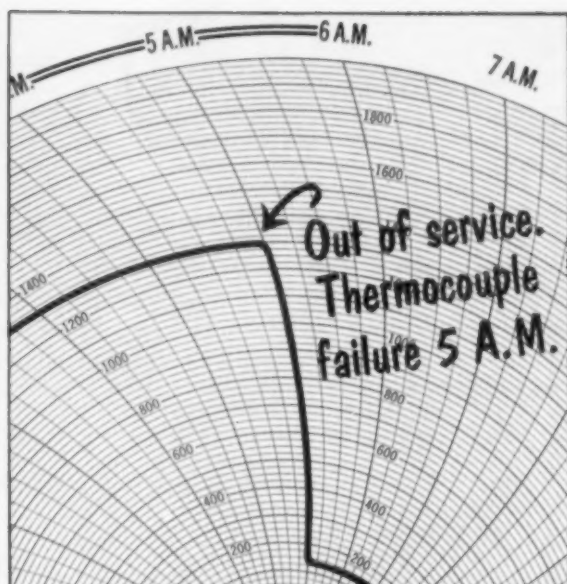


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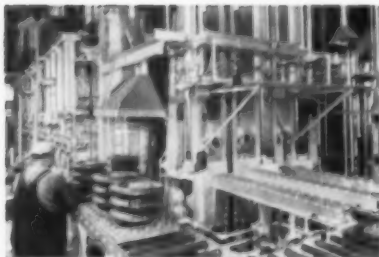
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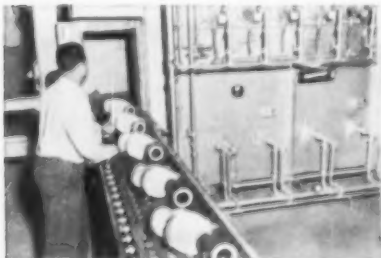


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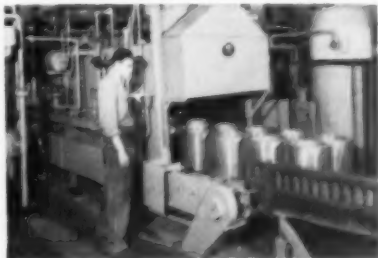
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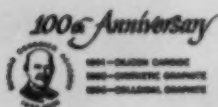
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